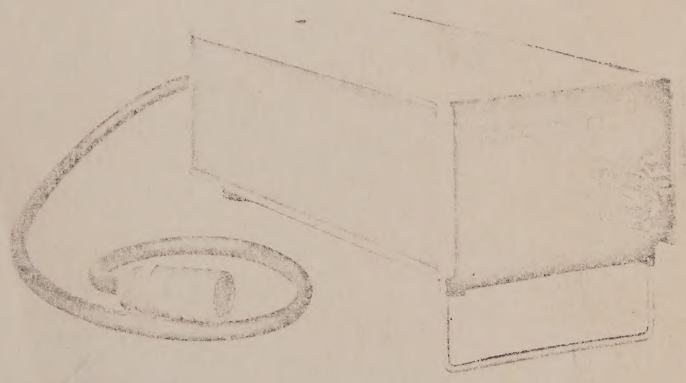
OPERATING AND SERVICE MANUAL

NULL DETECTOR

G2A & G2B



HEWLETT hp PACKARD

HP G2A/G2

OPERATING AND SERVICE MANUAL

TYPE G-2A & G-2B
NULL DETECTOR

Serial Prefix 000 thru 703

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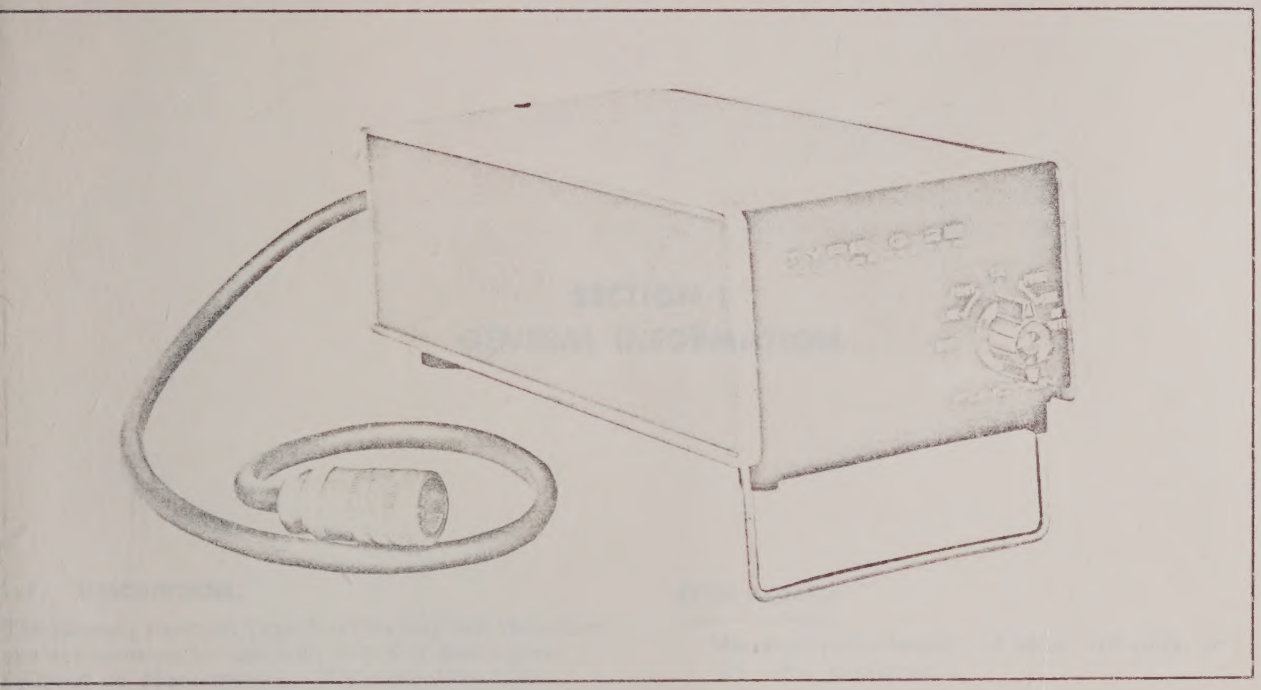


FIGURE 1-1. TYPE G-2B NULL DETECTOR

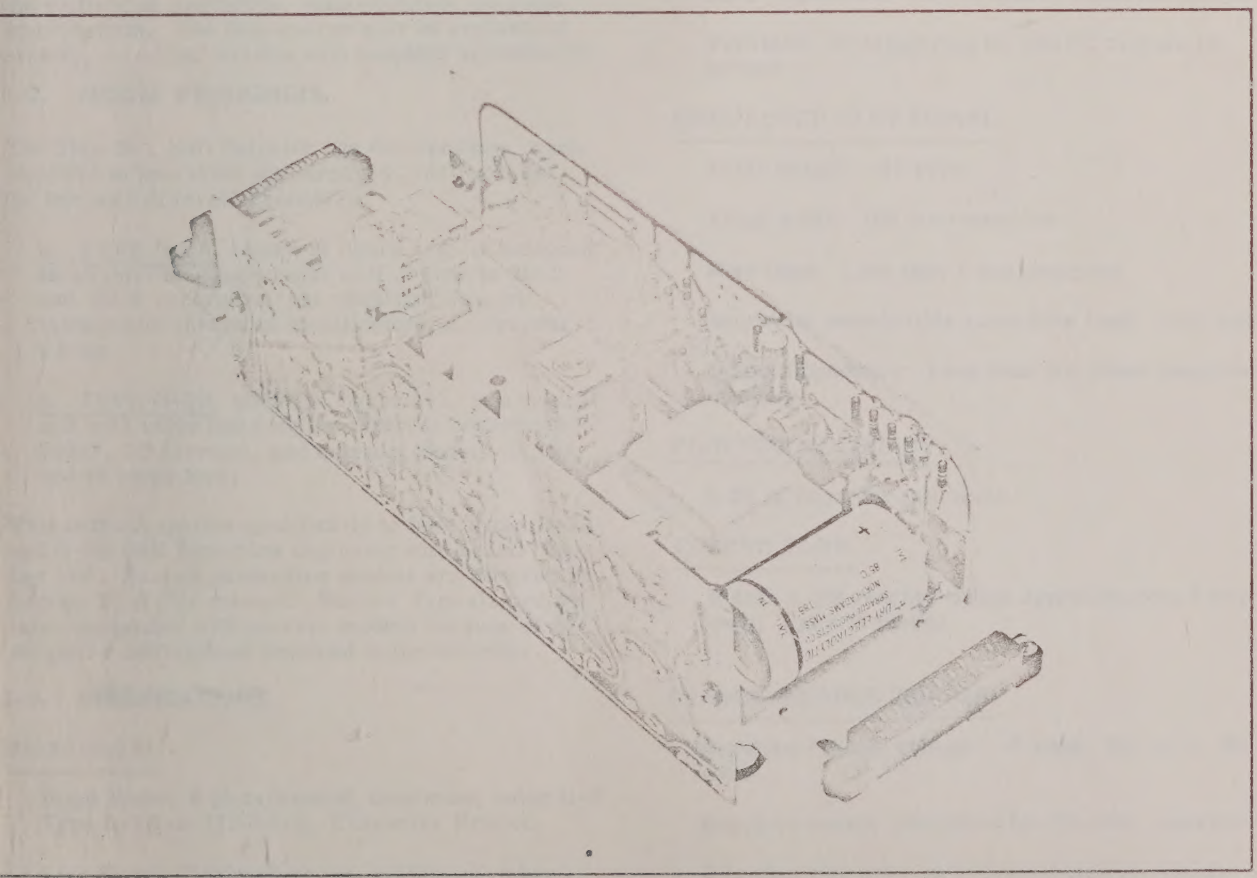


FIGURE 1-2. TYPE G-2A NULL DETECTOR

SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION.

The Hewlett Packard Type G-2 (Series) Null Detectors are accessories for use with H-P X-Y Recorders (without dc servo motors. Not compatible with 7035B, 7005B, and 7004A) to permit the plotting of analog data in discrete point form. The Null Detector controls the operating modes of the recorder during the plotting of continuous, discontinuous, or point function data. The data source may be any analog system, or digital system with adapting accessories.

1-2. MODEL DIFFERENCES.

The Type G-2 Null Detector has two versions, each identical in operation and circuitry, but packaged for use with different recorders:

a. TYPE G-2A, shown in figure 1-2, is designed as an internal plug-in unit in H-P Models 2D-2 and 2D-3 recorders, but requiring factory installation involving modification of recorder wiring.

b. TYPE G-2B, shown in figure 1-1, is a cabinet unit with cable and plug for external connection to 7000F, 2D (Series), and existing Models 2A, 2S, and 4S recorders.

This manual applies specifically to both Types G-2A and G-2B Null Detectors beginning with Serial Number 146. Earlier production models are covered in Section VI of this manual. Earlier Type G2 are not interchangeable with current models because of additional modifications required in the recorder.

1-3. SPECIFICATIONS.

PLOT RATE:

Point Mode: 6 plots/second, maximum, using H-P Type D-1B or 17009A/B, Character Printer.

Line Mode: 7 points/second, maximum, when points are displaced an average of 0.05 inches, and using a regular pen.

SEEK SIGNAL:

Minimum pulse height: ±3 volts; +10 volts, or -20 volts, maximum.

Minimum pulse width: 2 microseconds.

Input impedance: 15,000 ohms, capacitor coupled.

Provision for triggering by contact closure to ground.

COMPLETED PLOT SIGNAL:

Pulse height: +20 volts.

Pulse width: 100 microseconds.

Rise time: Less than 1 microsecond.

Maximum permissible capacitive load: .002 mfd.

Output impedance: Less than 200 ohms (capacitor coupled).

PLOTTING ACCURACY:

0.2% of recorder full scale.

FORCED PLOT:

If null is not reached within approximately 2 seconds, a plot is forced.

ENABLE-DISABLE SIGNALS:

Required disable voltage: -3 volts, DC up to -20 volts.

Required enable voltage: 0 to +20 volts, maximum.

A contact closure may be substituted for the disable bias by inserting a resistor between terminals on circuit board.

Provisions for reversing bias requirements.

A complete plot signal is used each time the unit is enabled.

CONTROLS:

Function selector for five operating modes: Mute-line, Mute-Point, Calibrate, No-Mute-Line, No-Mute-Point.

POWER REQUIREMENTS:

115 volts, 50/60 cps, 2 watts, single phase (supplied from the associated recorder).

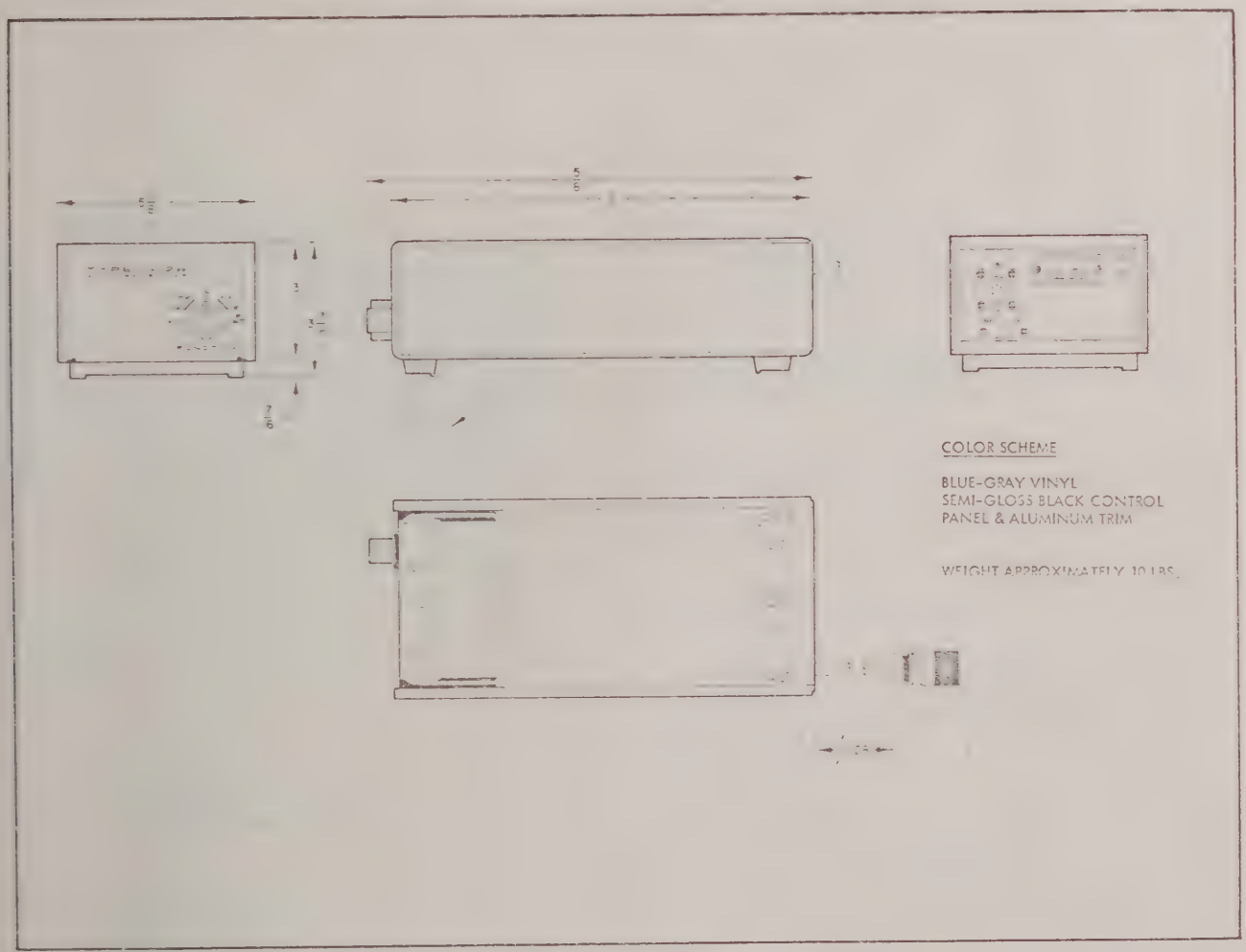


FIGURE 1-3. PHYSICAL DIMENSIONS OF G-2B

SECTION II
OPERATION

2-1. INTRODUCTION. The basic function of the Type G-2 Null Detector is to extend the capability of an X-Y recorder to include plotting of analog data in points or line segments. Useful in a variety of plotting systems, five operating modes are provided to meet plotting requirements in producing either line graphs with the normal recorder pen, or point graphs with a character printer replacing the pen. To realize full capability of the Null Detector in automatic system control of the recorder, pulse signals conforming to the acceptance characteristics of the detector unit must be provided from the system. These pulses trigger timing circuits in the detector which, in turn, generates control signals in the proper sequence to allow the recorder to null and plot at the ordered coordinates. Before installing the Type G-2 Null Detector in a recorder or system, the user should become familiar with the signal requirements and operating procedures as outlined in the following paragraphs.

2-2. ELECTRICAL REQUIREMENTS.

2-3. OPERATING POWER. Primary power requirements is 115 volts, 50/60 cps, furnished from the associated recorder.

a. TYPE G-2A. Power for this unit is obtained through pins on the chassis plug-in connector.

b. TYPE G-2B. Power for this unit is obtained through the connecting cable which plugs into the "DIGITAL" receptacle of the recorder.

CAUTION: Before connecting the Type G-2B, see paragraph 2-7 regarding type of amplifier used in the recorder.

2-4. EXTERNAL CONTROL SIGNAL CONNECTIONS. For complete automatic plotting, two control signals must be fed to the Null Detector from the recording system, and one control signal from the Detector to the recording system. These signals are:

a. SEEK PULSE. A signal furnished from some point in the plotting system to command the recorder to start a plot cycle.

NOTE: A seek pulse must be used if the Null Detector is used in the Point-No-Mate male and the minimum analog input step to the recorder is less than 1 inch.

b. ENABLE-DISABLE BIAS. A potential initiated automatically or manually from the system to start or stop operation of the Null Detector.

c. COMPLETED PLOT PULSE. A signal generated by the Null Detector for transmission to an appropriate point in the system to confirm a completed plot and indicate readiness for the next plot.

Connections for these signals for the two types of Null Detectors are made as follows:

a. TYPE G-2A. A recorder equipped with the plug-in Null Detector is supplied with a plug which mates to a rear receptacle on the recorder marked "Retransmitting Slidewire". Pin connections are indicated in Figure 2-1.

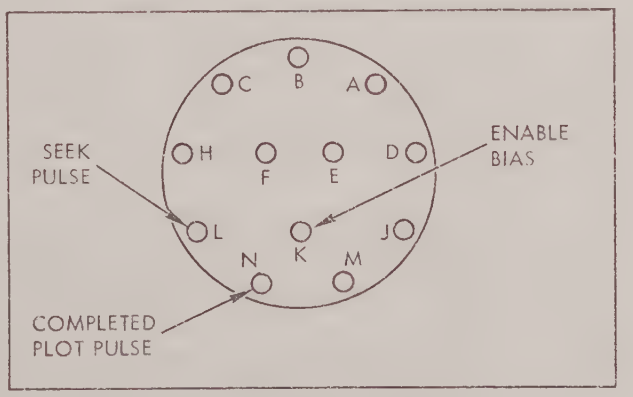


FIGURE 2-1. RECEPTACLE PIN CONNECTIONS FOR G-2A

b. TYPE G-2B. This unit is supplied with a rear receptacle and mating plug with pin connections as indicated in Figure 2-2.

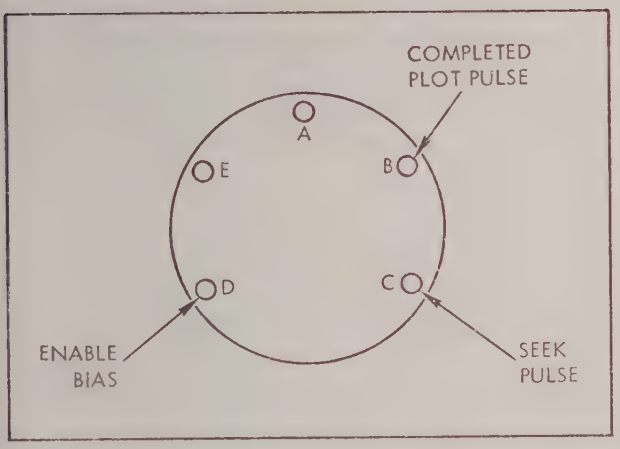


FIGURE 2-2. RECEPTACLE PIN CONNECTIONS FOR G-2B

2-5. OPERATING CONTROLS.

2-6. TYPE G-2A. A single selector, shown in figure 2-3, controls all the operating modes. On this model, access to the control is attained by sliding forward the control panel assembly of the recorder, exposing a small sub-panel mounted above the Y FUNCTION switch.

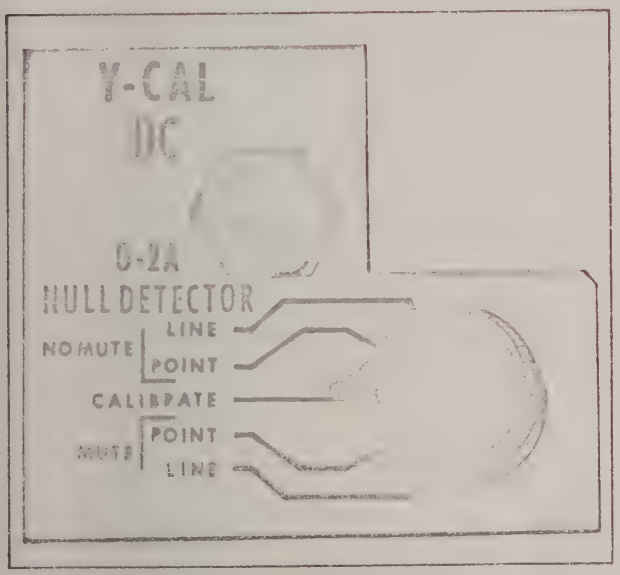


FIGURE 2-3. G-2A FUNCTION SWITCH

2-7. TYPE G-2B. On this model, the single control knob labeled FUNCTION is mounted on the front panel of the Null Detector (refer to figure 2-4). In addition, a slide switch on the rear panel is provided to adapt the unit for use with recorders having either vacuum tube or transistor type servo amplifiers.

CAUTION: The Function switch must be in a position corresponding to the type of amplifier used in the recorder. Incorrect positioning may result in damage to the recorder, null detector, or both.

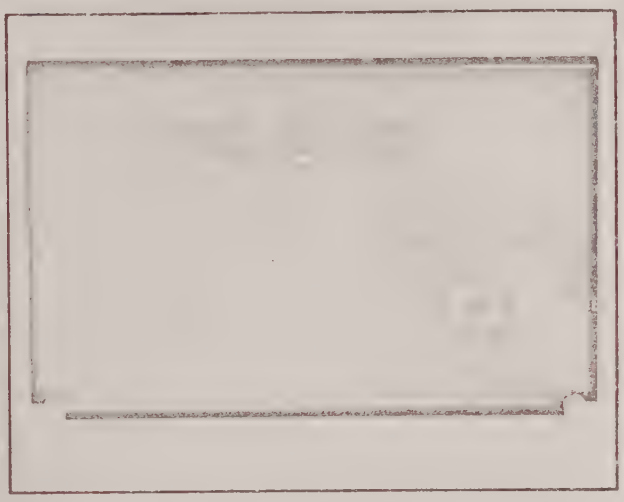


FIGURE 2-4. G-2B CONTROL PANEL

2-8. The selector control on both the G-2A and G-2B provides five operating modes as follows:

1. MUTE POINT. Used when operating with an HP Character Printer. In this mode, a seek pulse received by the detector unmutes the recorder servos, allowing the printer to move to the coordinates designated by the input data. At null, the servos become re-muted, the point is plotted, and a "completed plot" pulse is generated by the detector to indicate readiness for the next point.

2. MUTE-LINE. Used when operating with the standard recorder pen. In this mode, the initial plot cycle is similar to MUTE-POINT operation until the servos are re-muted on reaching the first coordinate position. There, the pen lowers to the paper where it remains during all succeeding plots. Provided the data points are sufficiently close together, straight line segments will be drawn between successive coordinates. Following the final plot cycle, the pen may be raised by an external command such as a DISABLE bias.

3. CALIBRATE. Used during standard operation of the X-Y recorder, or when calibrating external components of the system. In this mode, the recorder is not muted, it will balance at a designated coordinate but will not plot.

4. NO MUTE-POINT. Used when operating with an HP Character Printer. In this mode, the recorder balances automatically at the designated coordinates and plots without being muted if the recorder excursion is greater than one inch. A "completed plot" pulse is then generated by the null detector indicating readiness for the next cycle.

5. NO MUTE-LINE. Used when operating with the standard recorder pen. In this mode, the pen is

lowered to the paper shortly after null is reached. After the first plotting cycle, the pen remains in writing position through the last data point when it must be raised by an external command such as a disable bias.

WARNING: Use of a Character Printer in either of the LINE modes will result in overheating and possible damage to the printer solenoid.

SECTION III
THEORY OF OPERATION

1. CIRCUIT DESCRIPTION (refer to figure 3-2)

2. Paragraphs 3-3 through 3-9 provide a basic scription of each circuit within the Null Detector. more detailed description is provided in paragraph 10 and subsequent paragraphs.

3. NULL SENSOR. An error signal from the ecorder (always shifted 90 degrees from the line equency) is transformed by full wave rectification the Null Sensor to a negative pulsating signal. his signal passes through a buffer to a transistor vitch, triggered by the power supply at intervals rresponding to the peak values of the error signal. he resulting train of pulses, proportional to the ak value of the error signal, is routed to the ONTROL section. This section controls the mute, int plot, and force plot circuits. When null is nsed through an absence of error signal, a 100 illisecond delay starts, after which a signal is nt to actuate the mute relay and plot circuit. A me delay of 2 seconds is initiated in the force plot rcuit when the CONTROL circuit receives an ror signal.

4. PLOT CIRCUIT. A pulse from the Null Sensor the plot circuit indicates that null has been reached. hen in POINT-PLOT mode, a 40 millisecond pulse, hich corresponds to the instant the Character rinter starts to lift from the paper, triggers a lse in the completed plot circuit. In LINE-MODE, pen replaces the Character Printer and the same equence of events occurs for the initial pulse except e pen remains lowered. A 40 millisecond delay is t required before acceptance of the next error gnal, and the Null Sensor immediately triggers a lse in the completed plot circuit.

5. MUTE CIRCUIT. Upon detection of a voltage ange in the Null Sensor, the mute circuit unmutes e servo amplifiers and allows the servo to seek ll. No error signal appears at the Null Sensor while the Recorder is muted. When a voltage is received from the Null Sensor indicating null has been reached, the mute relay is de-energized, remuting the Recorder amplifiers. With the FUNCTION switch in either of the two mute positions, the Recorder remains muted until another "seek" pulse is initiated. This allows both X and Y functions to be entered separately without premature plotting of the first function. When the non-mute mode is utilized, although the mute circuit operates in an identical manner, the connecting wires between the mute circuit and the servo amplifiers are open, causing the Recorder to remain unmuted at all times. The mute circuit is also controlled by the ENABLE-DISABLE circuit.

3-6. COMPLETED PLOT CIRCUIT. Upon receipt of an internally generated pulse indicating that the plot has been accomplished, the completed plot circuit issues a pulse to the signal source confirming the completion of a plot cycle and indicating all circuits are ready for the next signal entry.

3-7. SEEK CIRCUIT. This circuit may be triggered by either a positive or negative pulse from an external signal source, or by closure of an external contact. When an external seek pulse is applied, heavy conduction fully discharges the timing capacitor shifting the monostable flip-flop in the control circuit to an unstable mode. The seek circuit is automatically switched to normal upon total discharge of this capacitor. When in either mute mode (LINE or POINT), a seek pulse is required to advance to the next point. The seek circuit is also used to initiate a plot cycle when the error signal is not large enough to trigger the CONTROL circuit. An error signal must be sufficient to move the Character Printer approximately 0.2 inch.

3-8. FORCE PLOT CIRCUIT. Each error signal received by the Null Detector initiates the charging of a capacitor in the force plot circuit. When the charge

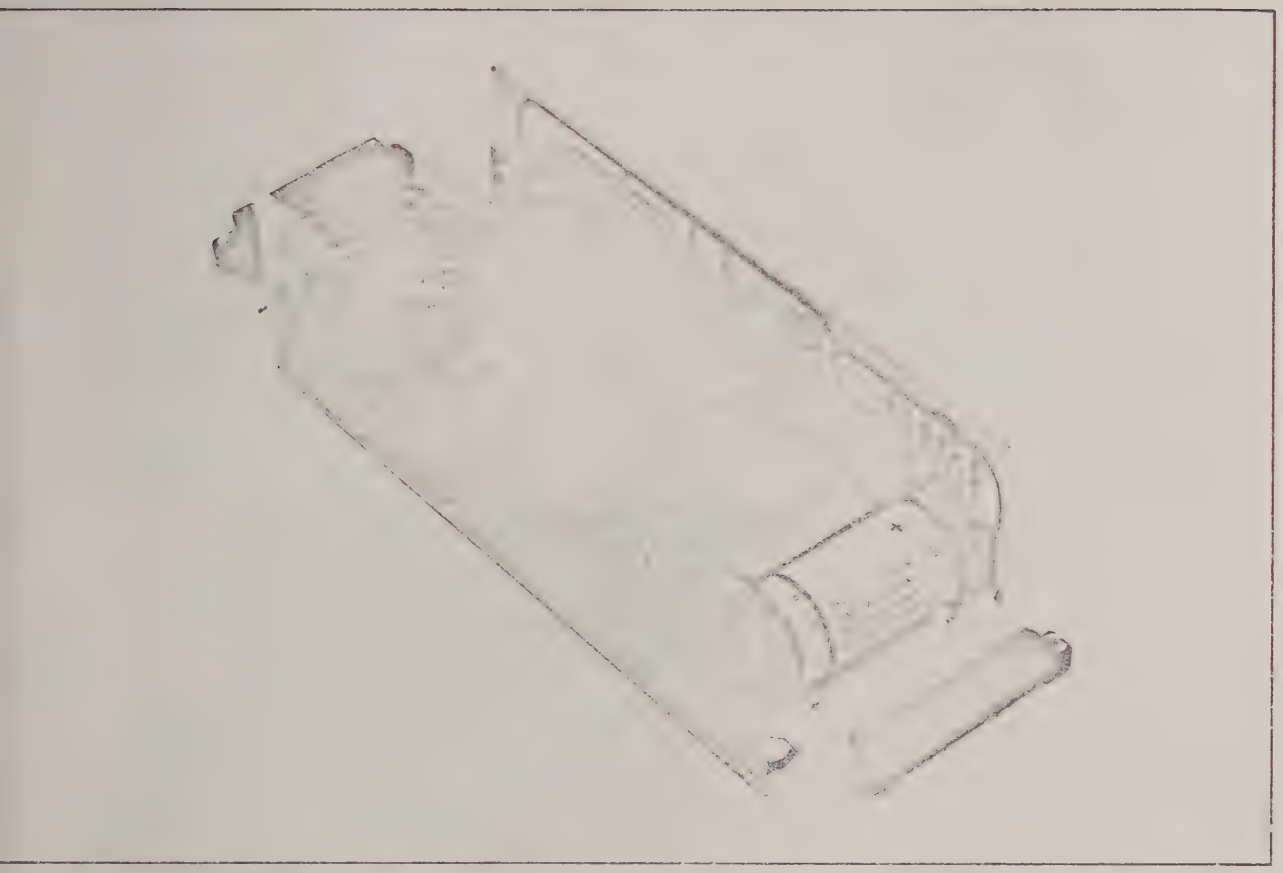


FIGURE 3-1. NULL DETECTOR PLUG-IN

s nearly completed (approximately 2 seconds), and if ull has not been reached, the error signal is can-eled before reaching the CONTROL section and a lot is forced. This condition will prevail when the nagnitude of a signal being plotted extends beyond the imits of the graph. In this case, a plot will be made long the margin of the paper until the signal returns vithin the graph limits.

-9. ENABLE (DISABLE) CIRCUIT. As shipped from he factory, zero voltage allows (enables), and a ninimum of -3 volts prevents (disables), plotting in he system. Reverse voltage values and polarities nay be used if jumper wires are changed as described n paragraph 5-8. Insertion of resistor R-218 (not upplied with the unit) into the ENABLE circuit will ermit control by the use of contact closures. Upon eceipt of a DISABLE command from an external ource, a voltage is applied to the plot circuit which locks actuation of the solenoid, thus preventing a lot by the Character Printer or pen. A voltage is lso applied to the MUTE circuit which, if the FUNC-TION switch is in a mute position, mutes the servo. The completed plot circuit is also controlled by the ENABLE circuit and is prevented from issuing a com-leted plot pulse. This completely disables the Null Detector and X-Y Recorder. After being disabled, n ENABLE voltage will cause a completed plot pulse o be issued.

3-10. DETAILED CIRCUIT DESCRIPTION.

3-11. DETAILED NULL DETECTOR CIRCUIT DESCRIPTION. The following is a more detailed description of the entire circuitry. Refer to the schematic for symbol number locations and to figure 3-2 for detailed block diagram.

3-12. RECTIFICATION AND SAMPLING. The AC servo error signal enters the Null Detector unit through coupling capacitors C-101 and C-102, and is rectified by a full wave bridge composed of diodes CR-101 through CR-104 and TR-101. The rectified output is routed through buffer transistor TR-102 to switching transistor TR-103 which samples the peak values of the error signal. Sampling occurs when the output voltage of full wave power supply rectifier CR-118 and CR-119 approaches zero. The trigger voltage, being in phase with the line voltage, is 90 degrees out of phase with the error voltage. For this reason, sampling occurs only at the peak value of the error signal. This sampling technique produces a null detector system insensitive to changes in amplifier noise level because the servo always positions at null with a minimum area under the error signal waveform in the vicinity of the sampling point. Hence, the output from TR-103 will consist of a train of negative pulses with amplitudes proportional to the peak value of the rectified error signal. These pulses are then sent to the control section.

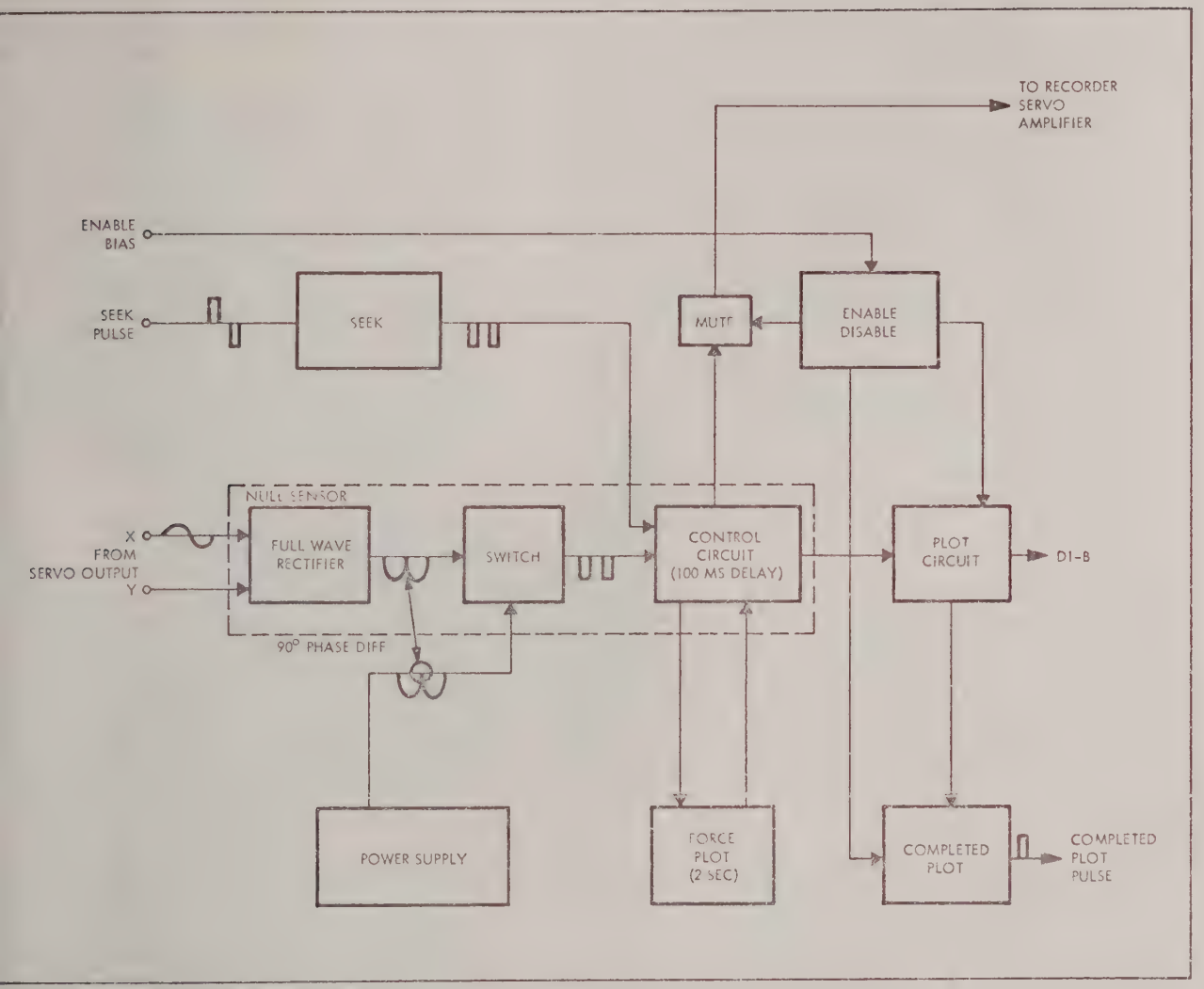


FIGURE 3-2. NULL DETECTOR BLOCK DIAGRAM

3-13. CONTROL SECTION. Sampling pulses from the switching transistor are changed to a DC voltage by the emitter follower TR-104 and capacitor C-103. This voltage triggers the monostable flip-flop to its unstable state, i.e., TR-105 "on" and TR-106 "off", resulting in a signal being sent through R-135 to the mute circuit for unmuting of the servo amplifiers. The absence of error pulses indicates null has been reached. In order to assure this and to prevent the possibility of plotting on an overshoot, approximately 100 millisecond time delay is required before the flip-flop is allowed to return to its stable state. This is determined by the time constant of capacitors C-103 and C-104. C-104 provides the time delay when the plotted points are close together; both capacitors when the points are more widely separated. When C-104 is charged and C-103 is discharged, the flip-flop assumes its stable state, a signal is sent to the mute circuit for remuting the Recorder, and a positive pulse is sent through C-106 to the plot circuit.

3-14. PLOT CIRCUIT. TR-107 and TR-108 control the plot relay K-301. When a pulse is received, TR-107 is turned "off" and TR-108 is turned "on" thereby energizing K-301 for a duration of approximately 40 milliseconds at which time a point is plotted. On completion of the plot, the flip-flop returns to its stable state and in so doing, sends a negative pulse to the completed plot circuit indicating the point has been plotted. When in LINE MODE, except for the initial point, the plot circuit is bypassed and the CONTROL section issues a pulse directly to the completed plot circuit.

3-15. COMPLETED PLOT CIRCUIT. When a negative pulse is received by the flip-flop, (transistors TR-208 and TR-209) it is triggered to its unstable state and generates a completed plot pulse (approximately 100 microseconds). This pulse may be sent to an external circuit for automatically advancing the next point to be plotted and to trigger a signal to the seek pulse circuit. TR-210 provides

output impedance, permitting the use of connector cables.

SEEK CIRCUITS. A seek pulse is required operating in either of the muted modes to unmute ervo amplifiers so that the error signal may be ted. When an error signal is of insufficient mag- and duration to trigger the flip-flop, a seek is required to initiate a plot cycle. An external is fed through the coupling capacitor C-201 to a ave rectifier consisting of diodes CR-201, CR- nd transistor TR-201, resulting in a negative to the flip-flop transistors TR-202 and TR-203. receipt of this pulse, the flip-flop will switch to stable state (TR-202 "off" and TR-203 "on"), cing an output of approximately -20 volts which lized to discharge capacitors C-204 and C-104. C-104 is discharged, the seek circuit flip-flop urned to its stable state and the plotting cycle is ted.

MUTE CIRCUIT. When the monostable flip- n the null sensor switches to its unstable state, a e in bias turns TR-109 "off" and TR-110 "on", energizing the solenoid of mute relay K-302. unmutes the Recorder as long as TR-106 remains unstable state. When it returns to its stable the bias voltage of TR-109 is restored to its al value turning TR-109 "on", TR-110 "off", eenergizing K-302. This process takes place time TR-106 switches, even if the FUNCTION h is in the non-mute mode; however, while in node, the circuit is opened between the relay ie Recorder preventing any mute commands reaching the servo amplifiers.

FORCE PLOT CIRCUIT. When TR-105 and 06 are triggered to their unstable state, a cur- change results at C-204 causing the capacitor to e, producing a time delay of two seconds which ly is sufficient for the Recorder to detect null. l is not reached during this period the bias of 04 changes sufficiently to switch the transistor This activates TR-205 blocking the error sig- TR-104, resulting in TR-105 and TR-106 detect- hat appears to be null and initiating the normal ng sequence.

3-19. ENABLE-DISABLE SIGNALS. When a negative voltage is applied to TR-206 from an external signal source or contact closure, TR-206 turns "on" producing a drop from -20 to approximately -2 volts output to the mute and completed plot circuits, and TR-207 turns "off" producing approximately -20 volts output to the plot circuit. This negative voltage to the plot circuit prevents the switching of TR-107 or TR-108, thereby disabling the plotting circuit. The relative positive bias voltage applied to the mute circuit holds TR-109 and TR-110 in their stable state, preventing the unmuting of the Recorder servo amplifiers. It should be noted that the FUNCTION switch always must be in a mute mode for the Recorder to be muted. the -2 v (approximately) bias voltage applied to TR-208 locks it in the stable state thus preventing the generation of a completed plot pulse. Either a positive voltage or zero voltage at R-219 will enable the unit again. In so doing, the voltage is changed across C-207 causing it to discharge. This switches TR-208 and TR-209 resulting in the generation of a completed plot pulse.

3-20. POWER SUPPLY. 115 VAC power from the associated Recorder is applied to the primary of transformer T-301. The secondary voltage, after being rectified by CR-118 and CR-119, is tapped to trigger the error voltage sampling switch TR-103 in the null sensor circuit. After further filtering by R-141 and C-301, it is applied across Zener diode CR-120, the resulting -24 VDC being distributed to all other sections of the null detector.

3-21. SENSITIVITY. The basic sensitivity of the null detector is better than 0.4% of full scale which is slightly less than the accuracy specification of the Recorder. This, plus the sampling technique described in paragraph 3-11, makes the null detector independent of Recorder noise level and operating characteristic changes. However, an overall system accuracy of 0.2% is usually attained due to the 100 millisecond delay between 'null detection' and 'plot'. Only on long plotter excursions, when the inertial damper flywheel may reach maximum velocity, will plotting accuracy approach 0.4%.

SECTION IV
MAINTENANCE

4-1. ELECTRICAL MAINTENANCE.

4-2. Six test points, see Figures 4-1 and 4-2, are provided in the Type G-2 Null Detector to aid in trouble shooting. Figure 4-5 illustrates waveforms to be expected at these points under varying conditions. Under unusual environmental conditions it may become necessary to clean the contacts of relays K-101 and K-102. To accomplish this, a plastic dust cover must be removed by carefully compressing the bottom of the cover to clear two locking tabs on the relay base, then pulling off. A high quality non-conductant contact cleaner such as H-P Contact Cleaner P/N 5080-3605 should be used.

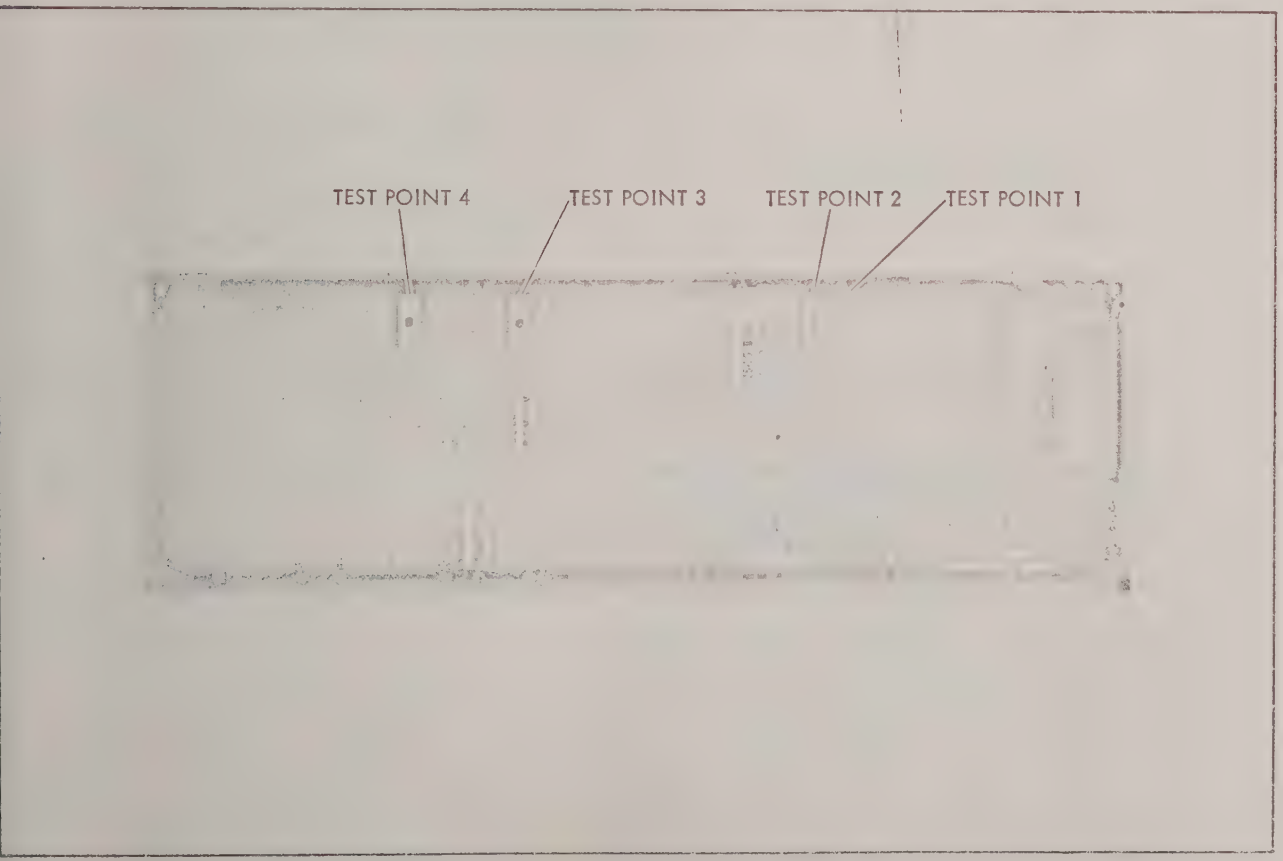


FIGURE 4-1. PRINTED CIRCUIT BOARD "A"

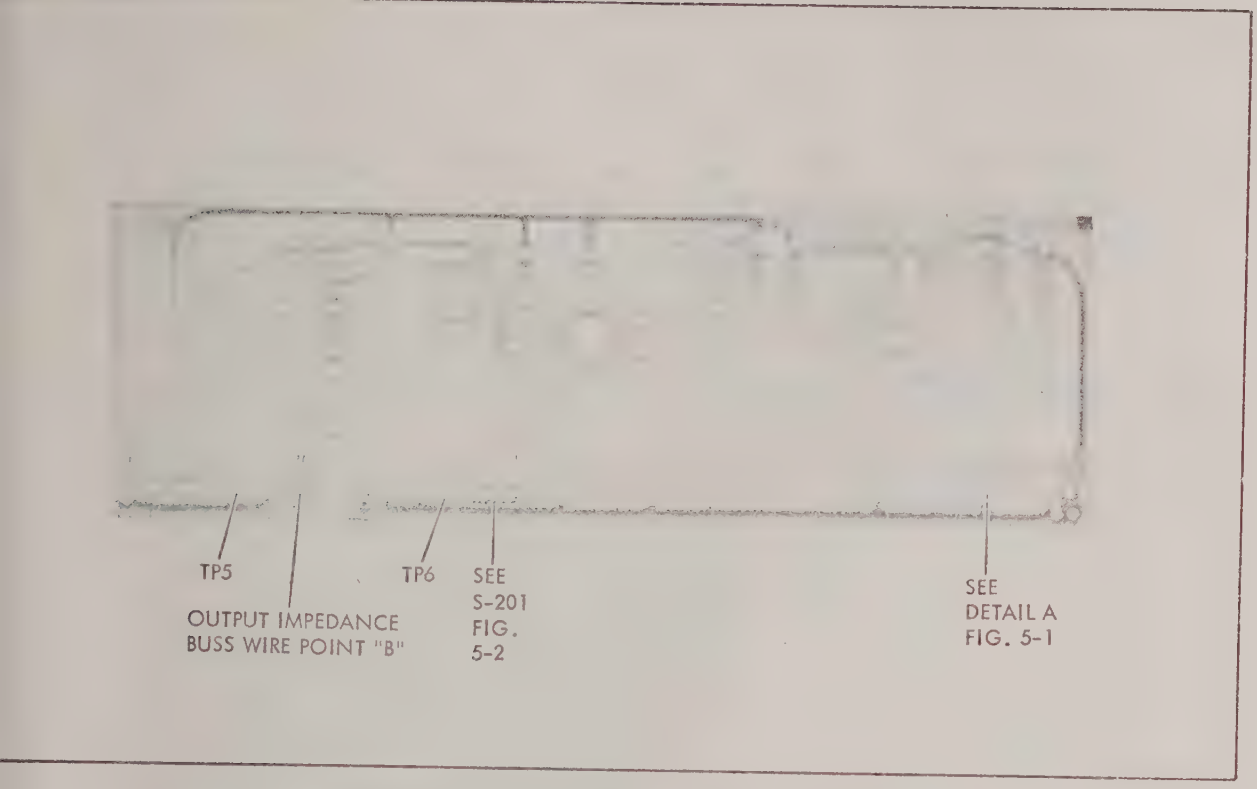


FIGURE 4-2. PRINTED CIRCUIT BOARD "B"

. REMOVAL OF NULL DETECTOR CHASSIS.

. TYPE G-2A (Plug-in Chassis). Removal of this from the X-Y recorder is easily accomplished. st remove the bottom cover pan from the recorder, four screws holding the null detector chassis in e (see figure 4-3). Pull the chassis from the re-ler vertically, being careful not to damage the nectors or Printed circuit board. Offset mount-of connectors prevents incorrect insertion. NOT FORCE INTO PLACE. The printed circuit ls are covered with insulation strips to prevent act with an adjacent plug-in unit within the re-er. For inspection or repair, these protective os must be removed, making sure they are re-ed before re-installing in the recorder.

TYPE G-2B. Removal of the Type G-2B chassis the cabinet is basically similar to removal of the G-2A from a recorder. Remove the top cover e cabinet by removing mounting screw and slide up and off. Remove chassis in a manner simi-o that used for Type G-2A (refer to figure 4-4).

SENSITIVITY CONTROL/ADJUSTMENT. The adjustment is the Sensitivity Control is Potentio-r R-106 which is set at the factory on Type G-2A and should not require readjustment unless other onents are changed. The usual setting of this ol is near fully CW. The Type G-2B, not being tory installed unit, may require readjustment of R-106 to provide optimum operation with the recorder used. The following procedure should be used:

a. Set the Function Switch in the POINT-NO MUTE Mode.

b. Remove cabinet top cover and locate R-106.

c. Turn the adjusting screw CCW until no plotting response is obtained after moving the carriage off null and releasing.

d. Begin to turn the potentiometer CW while continuing to move the carriage off null and releasing. Upon reaching a point where a plot is produced each time the carriage returns to null, a check of sensitivity should be made.

e. Manually move the pen in both X and Y directions allowing it to return to null each time. Four plots in the form of a cross should appear, the sensitivity being indicated by the space between the plots; the shorter the space, the greater the sensitivity. Adjustment should be continued until the desired degree of sensitivity is reached. Too high a sensitivity may result in double plotting. This may be eliminated by turning the potentiometer CCW.

NOTE: Readjustment for optimum performance may necessary if the Type G-2B is operated with several recorders.

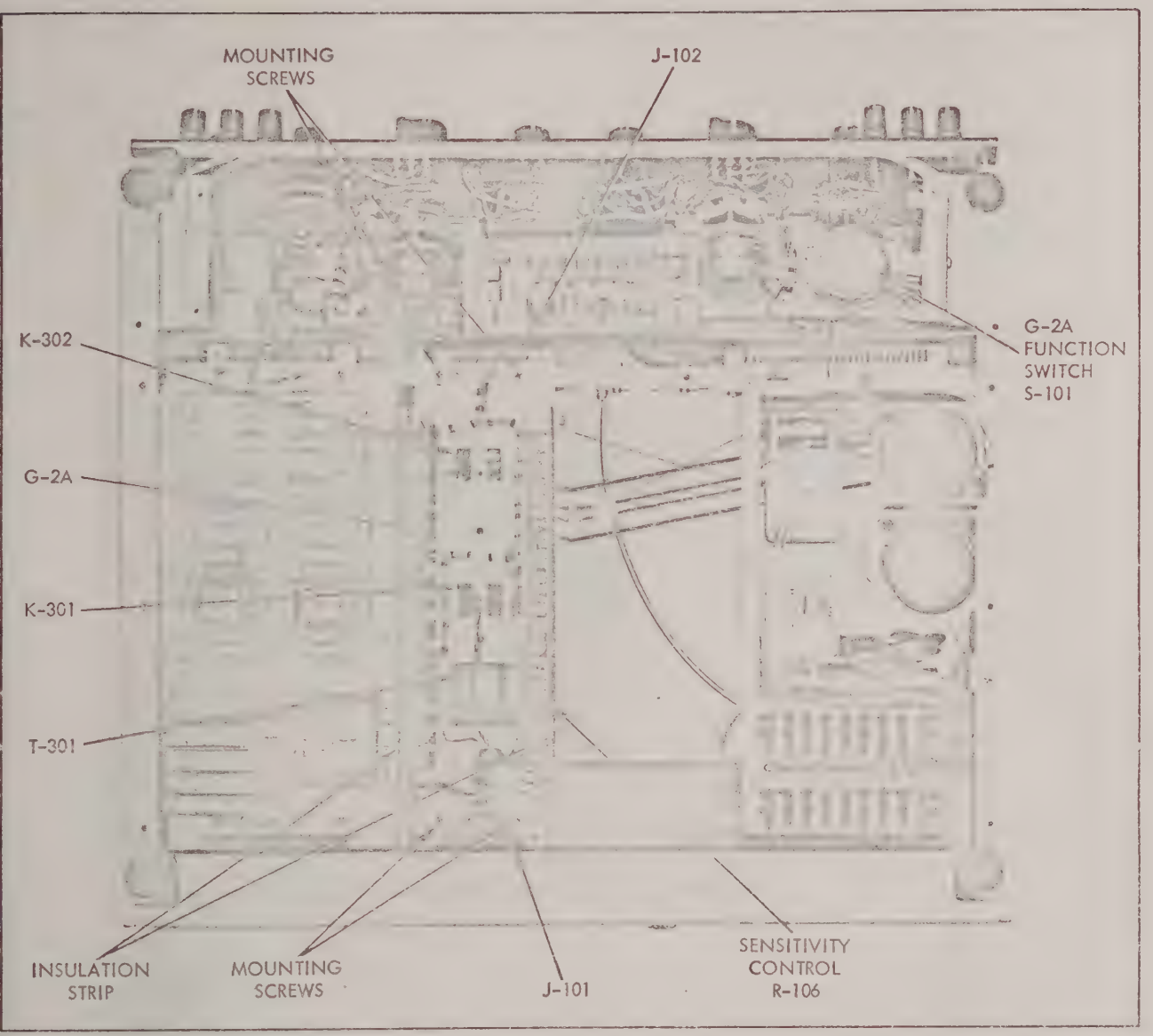


FIGURE 4-3. G-2A INSTALLED IN A MODEL 2D-2

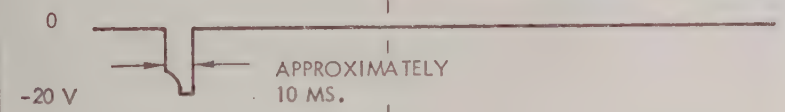
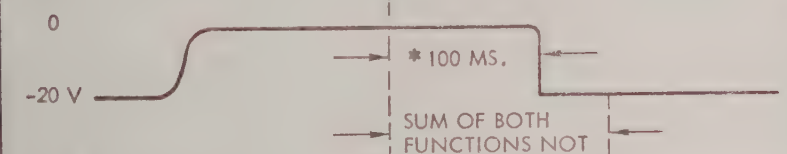
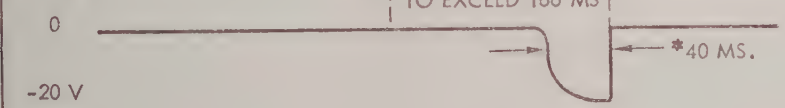
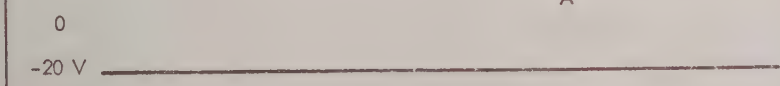
TEST POINT	WAVEFORMS (POINT-MUTE MODE)	MISCELLANEOUS COMMENTS
(SEEK SIGNAL INPUT)		Maximum permissible "seek" input pulse width is 80 ms. (see instructions)
T.P.1		-10 v. to -15 v. maximum error signal peak value
T.P.2		Small pulses may be present at null
T.P.3		Width will vary with operating mode and speed
T.P.5		100 ms. delay starts when error signal (TP2) disappears *100 ms. average 90 ms. minimum 130 ms. maximum
T.P.4		In "Line" mode pulse does not occur after pen drops *40 ms. average 30 ms. minimum 45 ms. maximum
COMPLETED PLOT OUTPUT		C. P. Pulse occurs at time "A" in "Line" mode *100 μs. average 85 μs. minimum 125 μs. maximum
T.P.6		-20 v, unit enabled -2 v, unit disabled
POWER SUPPLY		Approximately 50 mv. of ripple

FIGURE 4-5. TEST POINT SIGNAL CHART

SECTION V
MODIFICATIONS

5-1. MODIFICATIONS.

5-2. The following paragraphs provide information for various modifications to adapt the Type G-2 to a variety of plotting systems. These modifications may be performed by the user.

5-3. MUTE CONTROLLED BY ENABLE BIAS ONLY. System muting may be controlled only by the enable or disable bias by removing resistor R-135. In this mode of operation, the Function Switch must be in the mute position so that muting will occur when a disable bias is applied.

5-4. SEEK COMMANDS WITH PULSE WIDTHS GREATER THAN 80 MILLISECONDS. When negative seek command pulse widths exceed 80 milliseconds, it is necessary to move diode CR-201 (CR-216 for positive pulses) from its present location to position A and B (Figure 5-1). This will connect it to resistor R-203. Note that the polarity must be oriented opposite the diode that was not moved. For positive control pulses, CR-216 is moved in a similar manner. Failure to do this may result in the pulse's trailing edge also initiating a cycle.

5-5. SEEK COMMANDS BY CONTACT CLOSURES. Resistor R-201 permits the insertion of seek commands by simple contact closures. External closure devices should be connected between the input line and ground. If closure time exceeds 80 milliseconds, see paragraph 5-4.

5-6. CHANGING FORCE PLOT TIME. The normal delay time of 2 seconds before a plot is forced is controlled by the time constant of C-204, R-213. Other delay times may be established by changing the value of resistor R-213. A higher resistance will lengthen the delay and a smaller resistance will shorten the delay.

5-7. ENABLE CIRCUIT OPERATION BY CONTACT CLOSURE. This modification consists of installing R-128 (Note 4, schematic MD 12726). An external contact closure to ground will now be equivalent to a positive bias to operate the enable circuit.

5-8. ENABLE-DISABLE CIRCUIT CONTROL REVERSAL. If desired, the polarity requirements of the Enable-Disable Circuit may be reversed so that -3 VDC will ENABLE rather than DISABLE, or a contact closure to ground will DISABLE rather than ENABLE. This condition is established by relocating two jumper wires on Circuit board B, Figure 5-2. Normal position of these jumpers is shown in dark lines and reversed position in dashed lines.

NOTE. The jumpers should not be reversed if the Enable-Disable circuit is not to be used. Reversal establishes the Disable condition at all times when a negative bias is not applied.

5-9. INCREASING OUTPUT IMPEDANCE OF COMPLETED PLOT PULSE. The output impedance is normally low for use with long connector cables. If a higher output impedance is required, replace the jumper referred to in Note 6, schematic MD 12726 with a resistor corresponding to the increase desired. (See Figure 4-2, point B.)

WARNING: THE COMPLETED PLOT PULSE OUTPUT CABLE MUST BE SHIELDED TO MINIMIZE ELECTROSTATIC COUPLING TO THE SEEK CIRCUIT INPUT.

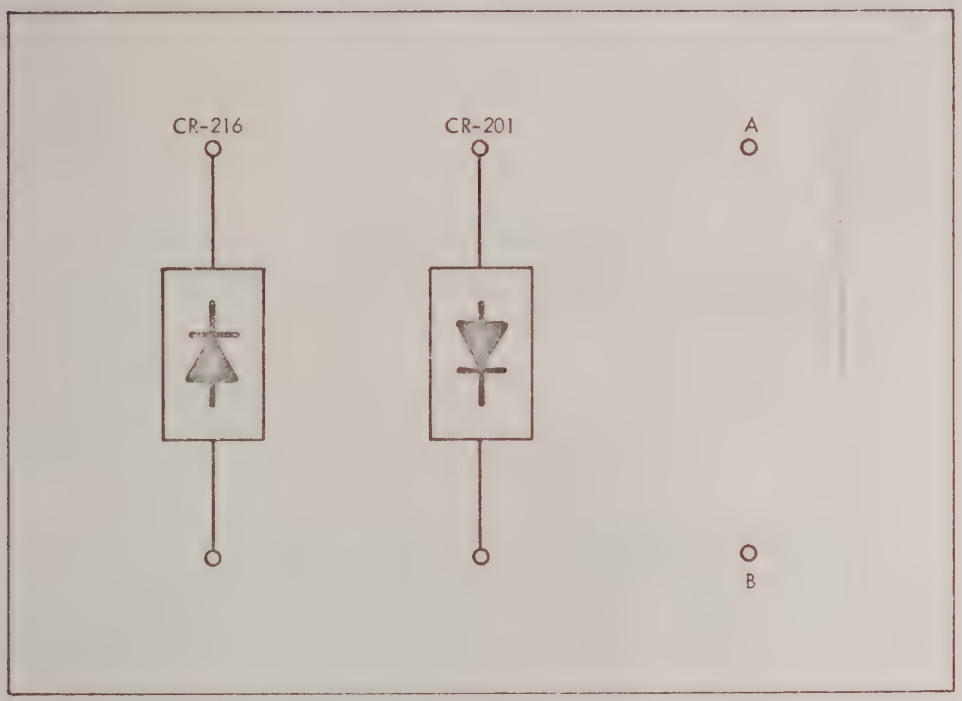


FIGURE 5-1. DETAIL A ON FIGURE 4-2.

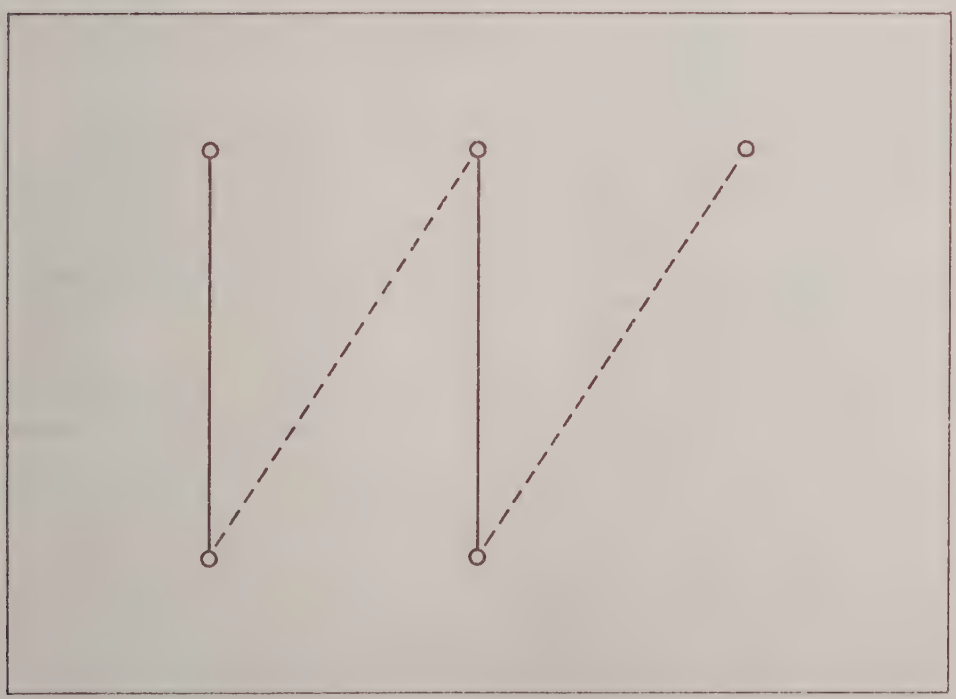


FIGURE 5-2. DETAIL OF S-201 ON FIGURE 4-2.

SECTION VI

TYPE G-2A AND G-2B (Serial No's 1 through 145)

6-1. DESCRIPTION. (Early production models)

6-2. Prior to serial number 146, G-2A and G-2B Null Detectors had major differences from current models and are not interchangeable. This section applies specifically to units with serial numbers 1 through 145.

6-3. SPECIFICATIONS.

PLOT RATE:

Plot Mode: 6 plots/sec. maximum (using D-1B, 17009A, 17009B Character Printer).

Line Mode: (typical - points displaced 0.05"): 10 points/sec.

SEEK SIGNAL:

Minimum pulse height: ±3 volts (+10 or -20 volts, maximum).

Minimum pulse width: point plot, 10 microseconds.

Minimum pulse width: line plot, 20 microseconds (80 microseconds for pulse heights less than 5 volts).

Polarity: + or -

Input impedance: 15,000 ohms, capacitor coupled.

COMPLETED PLOT SIGNAL:

Pulse height: +15 volts.

Pulse width: 100 microseconds.

Rise time: less than 1 microsecond.

Maximum permissible capacitive load: .002 mfd.

Output impedance: 5000 ohms, capacitor coupled.

PLOTTING ACCURACY:

0.2% of recorder full scale.

FORCED PLOT:

If a null is not reached within approximately 3 seconds, a plot is forced.

ENABLE - DISABLE BIAS (Refer to Section D-3):

Required disable voltage: 3 to 20 vdc.

Required enable voltage: 0 to +20 vdc.

Input impedance: 15,000 ohms, minimum.

A relay contact closure may be substituted for the disable bias by installing a jumper on the printed circuit board.

Reversal: Voltage or contact closure requirements may be reversed by moving a jumper on the printed circuit board.

CONTROLS:

Function selector for 5 operating modes: Mute-line, mute-point, calibrate, no-mute-line, no-mute-point.

On G-2B only: selector for adapting to tube or transistor type recorders.

POWER REQUIREMENTS:

115/230 volts, 50/60 cps, 1 watt, single phase, supplied from recorder.

6-4. CONTROL FUNCTIONS.

6-5. INPUT-OUTPUT CONTROL SIGNALS.

a. SEEK SIGNAL. Will accept a seek signal allowing external triggering of the null detector. Upon

eiving the signal, the null detector automatically l sense a null and force the character printer to plot.

b. COMPLETED PLOT PULSE. Upon completion a plot, the null detector generates a pulse which y be used to trigger or advance external equip- nt.

c. ENABLE - DISABLE BIAS. Enables operator stop or start both the recorder and the null de- tor. The bias requirements may be altered or minated as indicated in Section D-3.

. FUNCTION SWITCH.

a. CALIBRATE. The calibrate position stops the eration of the null detector so that the recorder may used independently or so that the system may be ibrated. In this position the point plotter or the n can be activated only by the pen switch on the corder.

b. POINT PLOT (No Mute). In this position, the nt plotter is activated automatically each time the ector senses null. Since the recorder is not muted, null detector will be triggered by either a seek or or signal generated by the recorder.

c. POINT PLOT (Mute). Operation is the same as -mute except only a seek signal will trigger the l detector.

d. LINE PLOT (No Mute). In this mode, a stand- d recording pen is substituted for the character nter (DO NOT USE A CHARACTER PRINTER IN IS MODE AS IT WILL BE DAMAGED DUE TO ERHEATING). After the first null is reached the n drops to the paper and remains down from point point until (a) the disable bias is applied, (b) the ction switch is placed in the calibrate position, or the power is turned off.

TE: In this mode the points being plotted must be very close together. Provided they are sufficiently close, approximately straight line segments will be drawn between successive data points.

7. RECORDER TYPE SWITCH (G-2B Only). Lo- ted on the rear of the G-2B unit, proper place- ent of this switch allows the G-2B null detector to compatible with both vacuum tube and transistor- ed recorders.

8. **OPERATING INSTRUCTIONS.** (early production odels).

9. TYPE G-2A.

a. Connect appropriate control signals to the dicated pins of the re-transmitting slidewire plug cated on the rear of the recorder (refer to sche- atic).

b. Set the function switch (located inside the re- corder drawer) at calibrate. At this time the entire system may be calibrated and the point plotter may be activated by the pen switch on the recorder.

c. After selecting desired function, the unit is ready to operate.

6-10. TYPE G-2B.

a. Before operation, place recorder TYPE switch (located on rear panel) in a position corresponding to the type recorder being used. Select VAC for vacuum tube equipped recorders, and TRANS for all transistorized recorders. Incorrect TYPE selection may cause failure of the protective internal fuse.

b. Connect the cable of the G-2B to the appropriate receptacle on the recorder.

c. Connect the appropriate control signals through the receptacle located on the rear of the Type G-2B.

d. Place the front panel function switch in the calibrate position. The entire system may be calibrated and the point plotter may be activated by the pen switch on the recorder.

e. After selecting desired function, the unit is ready to operate.

6-11. ADDITIONAL INFORMATION.

a. REVERSAL OF ENABLE BIAS REQUIREMENTS. As shipped from the factory the unit requires an enable bias as indicated in paragraph 6-3. By placing a jumper at tie points B on the circuit board, a relay closure to ground may be substituted for bias requirements. This would be equivalent to a positive bias. A reversal of the enable-disable bias requirements may be achieved by changing the jumpers at tie point A. To obtain a reversal of the requirements stated in the specifications, tie points 1 and 3 should be jumpered instead of tie points 1 and 2. If an enable bias is not to be used, the jumper at tie point A should be removed entirely.

b. MUTE CONTROLLED BY ENABLE BIAS ONLY. If muting is required only when an enable or disable bias is present, resistor R-137 may be removed from the circuit and R-138 changed to 10K. In this mode of operation, the function switch should be kept in a mute position so that a mute will occur when a disable bias is applied.

6-12. CIRCUIT DESCRIPTION.

6-13. The servo error signal is coupled to the null detector through C-101 and C-102 (X and Y axes). The output of transistor TR-101 is the rectified sinusoidal error signal. This signal is sampled by TR-103 when the voltage in the power supply at the junction of CR-118 and CR-120 is approximately zero volts. Because the error signal is 90° out of phase with the line voltage, this sample will always occur at peak values of the error signal. The output of TR-103 will therefore be negative pulses, the amplitudes of which are equal to the peak value of the error

gnal. At null no pulses will be present and any eady state noise from the recorder will not be de- cted due to the time interval selected for sampling.

-14. The pulses are applied to a mono-stable flip- op (TR-105 and TR-106) causing it to become un- able. The time required to return to a stable state ter reaching null is typically 100 μs, controlled by -103 and C-105. The mute relay controlled by TR- 10 is triggered by this flip-flop. When the flip-flop ecomes stable at null, a negative puise is transferred the flip-flop actuating the plot relay (TR-108 and R-109) which is energized for approximately 60 μs. t the completion of a plot or a return to a stable ate, a negative pulse is transmitted through C-114 to mono-stable flip-flop composed of TR-117 and TR- 18, which generates a completed plot pulse. This ılse is roughly 15 volts in amplitude and 100 μs ng and is generated when the character printer com- etes the plot.

-15. Coupling capacitors C-106 and C-108 attenuate ıy transients caused by on-off operation.

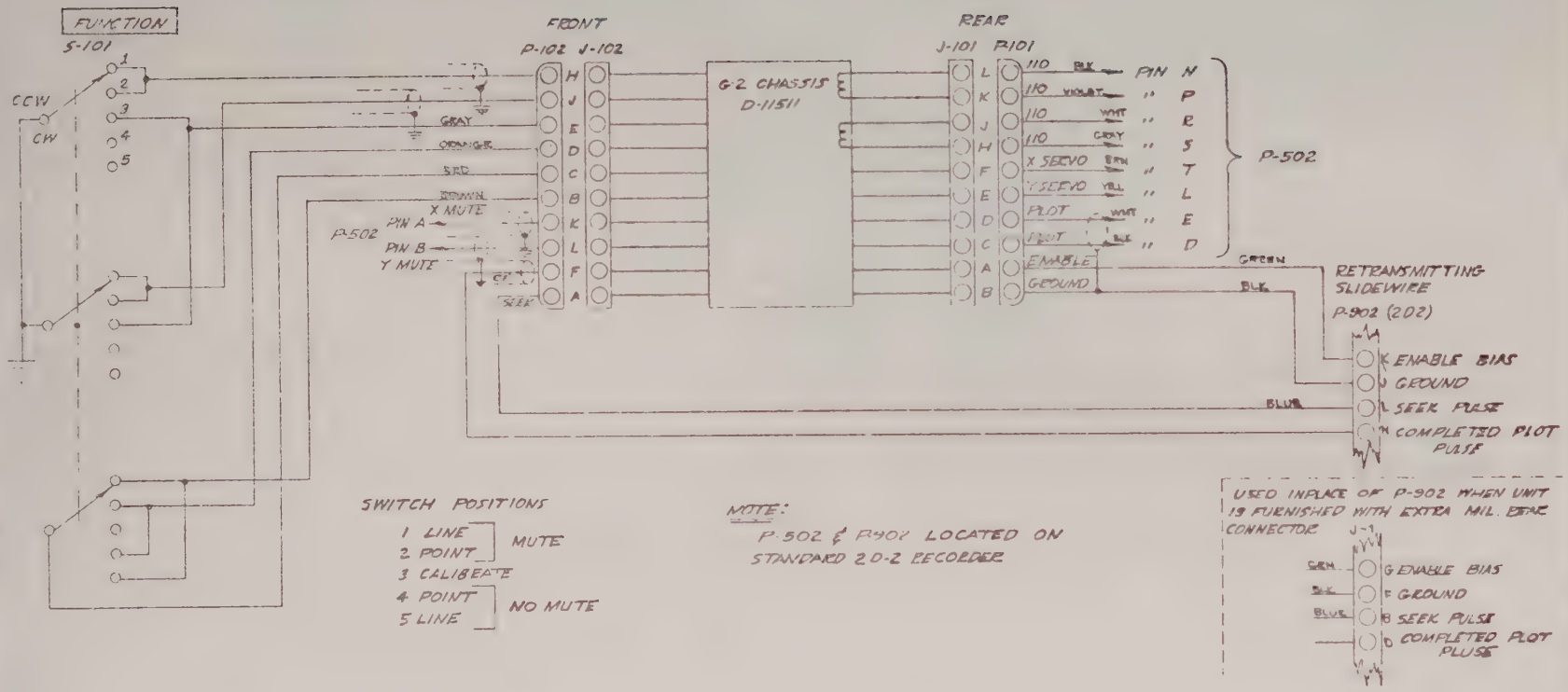
-16. The force plot circuit, composed of transistors R-111 and TR-112,operates a signal to force a ot and issue a completed plot signal three seconds ter the unit senses an error signal. The timing cir- uit is C-111 and R-141. At the completion of each ot, the diode CR-123 discharges C-111 so that the timing cycle may restart.

6-17. Diode CR-124 discharges the timing capacitor when plotting a continuous line at its maximum rate.

6-18. The seek circuit is composed of transistors TR-113 and TR-114. Its input is coupled through C-112 with negative seek pulses being passed through CR-126. A pulse applied through this circuit will trigger the flip-flop composed of TR-105 and TR-106, the same as an error signal.

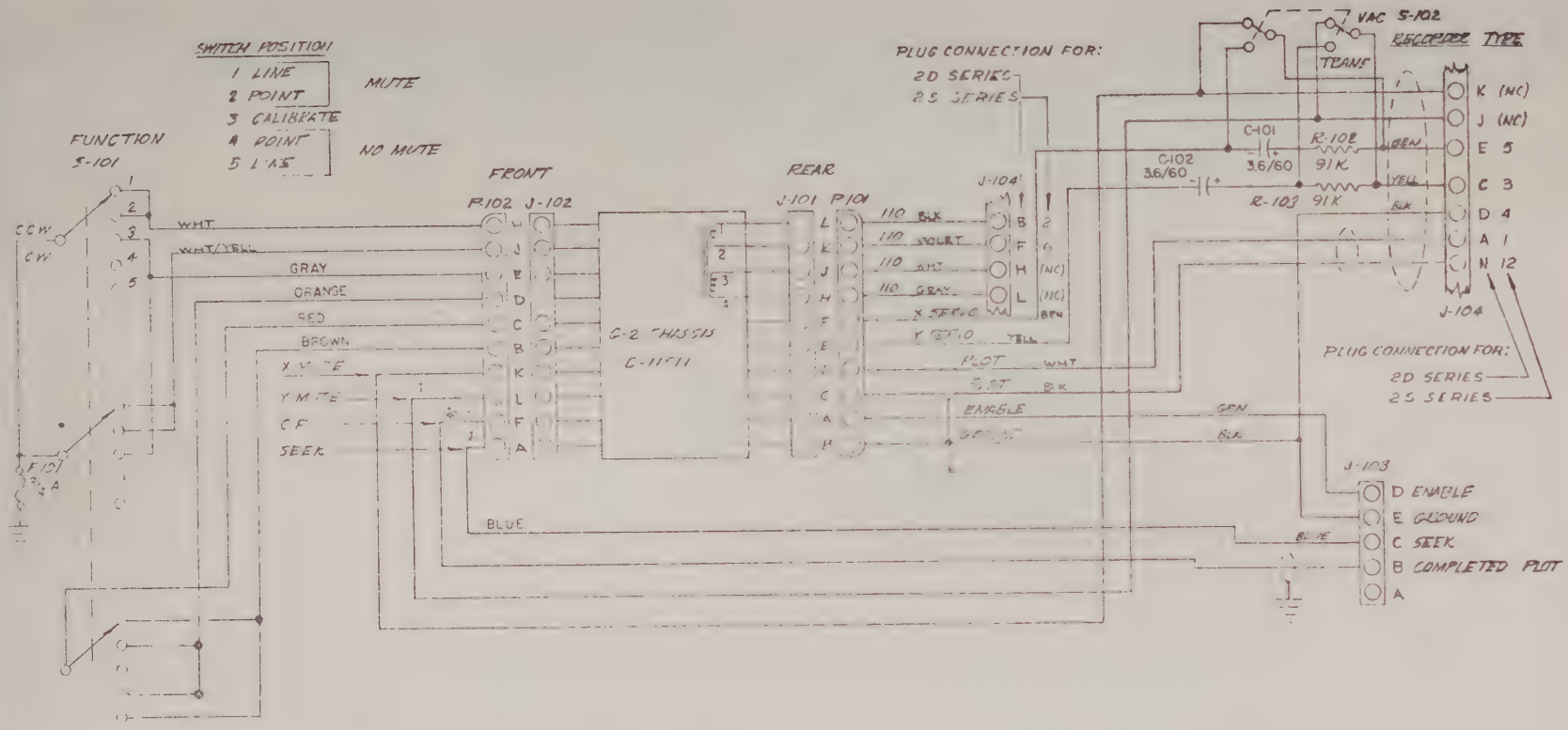
6-19. The enable or disable circuit is composed of transistors TR-115 and TR-116. Two sets of jumpers are provided to modify this stage to fit individual customer's requirements. A jumper may be placed at point B on the schematic of the circuit board to allow the unit to be enabled or disabled by a contact closure to ground. Moving of jumper at point B reverses the polarity of the required enable and disable bias.

6-20. The completed plot circuit is composed of transistors TR-117 and TR-118. In normal point plotting, the completed plot flip-flop is triggered by pulses through capacitor C-114 except for a pulse transferred through C-116 when an enable bias is applied. When in the continuous line plotting mode, the first completed plot pulse goes through C-114; all succeeding pulses go through C-115.

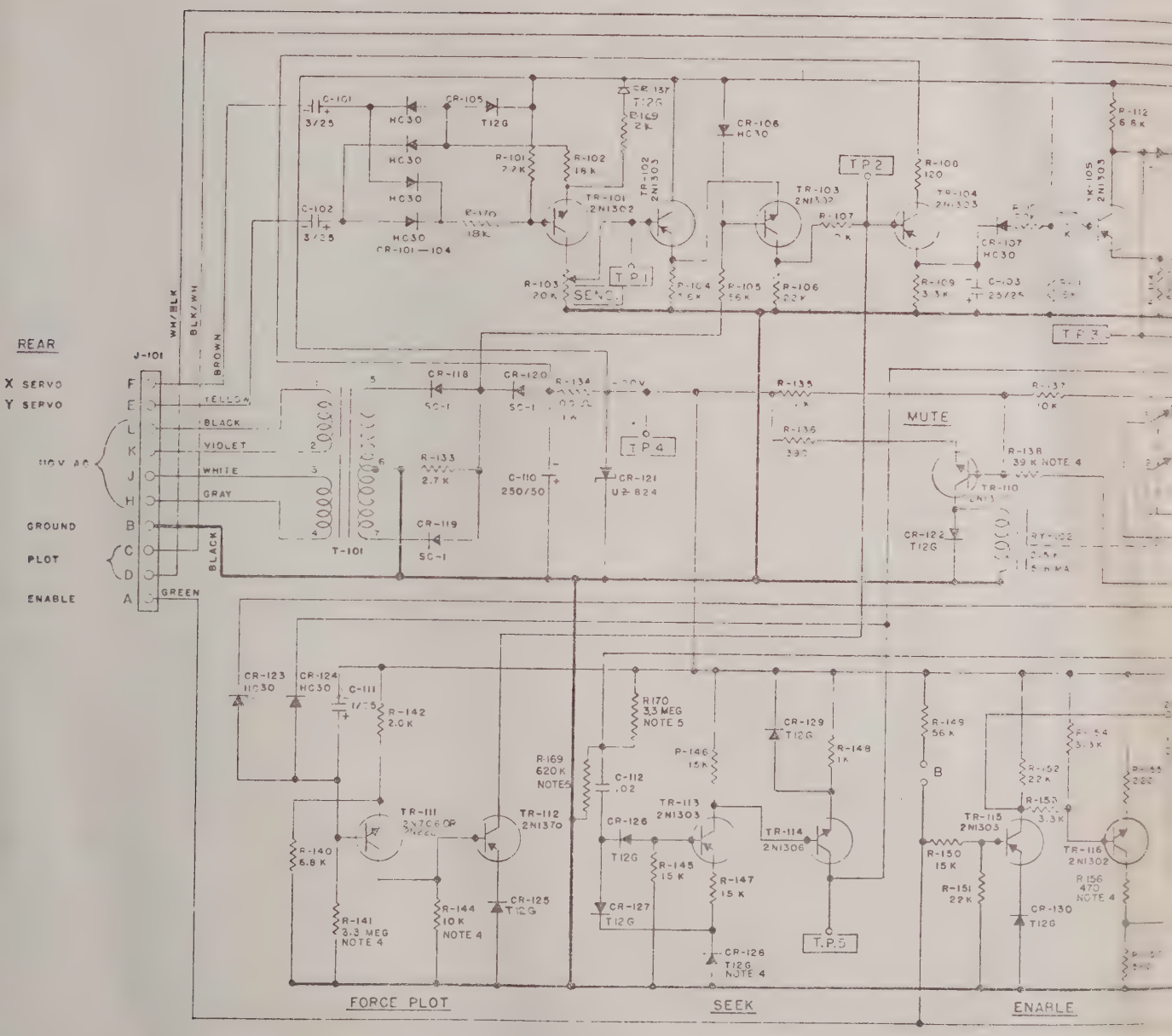


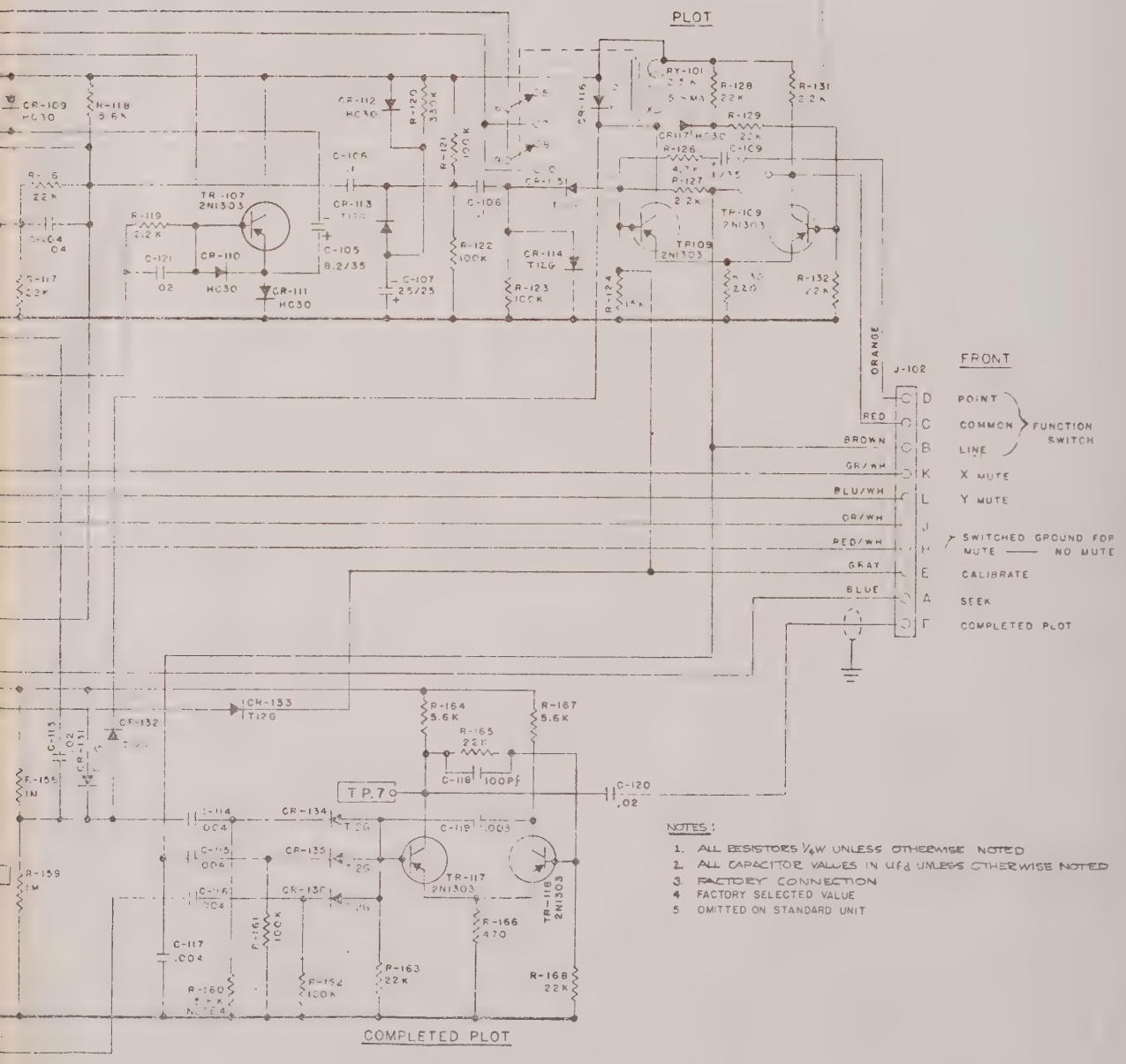
G-2 WIRING CONNECTIONS
WHEN INSTALLED IN 2D-2
Model G-2A S/N 145 AND BELOW

B-11675



TYPE G-2 NULL DETECTOR
INSTALLATION S/N 145 & BELOW B-11674
Model G-2B


REAR
J-101
X SERVO
Y SERVO
110 V AC
GROUND
PLOT
ENABLE
WH/BLK
BLK/WH
BROWN
BLACK
YELLOW
BLACK
VIOLET
WHITE
GRAY
GREEN
T-101
C-101
3/25
C-102
3/25
HC30
CR-101—104
CR-105
T12G
R-101
2.7K
R-102
18K
R-170
18K
TR-101
2N1302
TR-102
2N1303
CR-137
T12G
R-169
2K
CR-106
HC30
TR-103
2N1302
R-107
2K
TP2
R-100
120
TR-104
2N1303
CR-107
HC30
R-112
6.8K
TR-105
2N1303
R-103
20K
SENS
TP1
R-104
56K
R-105
56K
R-106
22K
R-109
3.3K
C-103
25/25
TP3
CR-118
SC-1
CR-120
SC-1
R-134
1K
TP4
R-135
1K
R-136
330
MUTE
R-137
10K
R-138
39 K NOTE 4
TR-110
2N13
CR-122
T12G
R-133
2.7K
C-110
250/50
CR-121
UZ 824
CR-119
SC-1
CR-123
HC30
CR-124
HC30
C-111
1/35
R-142
2.0K
R-140
6.8 K
R-141
3.3 MEG
NOTE 4
TR-111
3N76 OR
SK22
TR-112
2N1370
R-144
10K
NOTE 4
CR-125
T12G
R-169
620K
NOTE 5
C-112
.02
R170
3.3 MEG
NOTE 5
R-146
15K
CR-126
T12G
CR-127
T12G
TR-113
2N1303
R-145
15 K
R-147
15 K
CR-128
T12G
NOTE 4
CR-129
T12G
R-148
1K
TR-114
2N1306
T.P.5
R-149
56 K
B
R-150
15K
R-151
22K
TR-115
2N1303
R-152
22 K
R-154
3.3K
R-155
220
R-153
3.3K
TR-116
2N1302
R156
470
NOTE 4
CR-130
T12G
FORCE PLOT
SEEK
ENABLE



NOTES:

1. ALL RESISTORS ½W UNLESS OTHERWISE NOTED
2. ALL CAPACITOR VALUES IN µfd UNLESS OTHERWISE NOTED
3. FACTORY CONNECTION
4. FACTORY SELECTED VALUE
5. OMITTED ON STANDARD UNIT

TYPE G-2 NULL DETECTOR
MODEL G-2
S/N 145 & BELOW

D-11511

SECTION VII
PARTS LIST
G-2A & G-2B

7-1. RECOMMENDED SPARES.

7-2. This section lists all components on the schematic and items with mortality experience. Recommended spare parts for maintaining the instrument for one year period are designated in column RS.

7-3. ORDERING.

7-4. When ordering parts, the instrument type and complete serial number should be included with the description as given in this section. To order a part not listed, describe the item, its location, and functions. Orders and inquires should be placed with your area field office.

Circuit Symbol	HP Part No.	Description	Typical Mfrs	Mfrs Designation	RS
C-101	0180-1729	Capacitor, elec, 1 uf, 25 v. N.P.	Sprague	TVL 1621	1
C-102	0180-1729	Capacitor, elec, 1 uf, 25 v. N.P.	Sprague	TVL 1621	
C-103	0180-0338	Capacitor, elec, 25 uf, 25 v.	Sprague	TE 1207	1
C-104	225-0015	Capacitor, Tant, 8.2 uf, 35 v.	T. I.	SCM825GPO35A2	2
C-105	238-0022	Capacitor, 0.05 uf, 100 v.	AEROVOX	TTD	
C-106	0160-2057	Capacitor, 0.005 uf, 100 v.	AEROVOX	TTD	
C-107	0180-1729	Capacitor, elec; 25 uf, 25 v.	Sprague	TE 1207	
C-108	0180-0161	Capacitor, Tant, 3.3 uf, 35 v.	T. I.	SCM335BPO35A2	2
C-201	238-0022	Capacitor, 0.05 uf, 50 v.	AEROVOX	TTD	2
C-202	0160-2057	Capacitor, 0.005 uf, 50 v.	AEROVOX	TTD	
C-203	0160-2057	Capacitor, 0.005 uf, 50 v.	AEROVOX	TTD	
C-204	0180-1708	Capacitor, Tant, 8.2 uf, 35 v.	T. I.	SCM825GPO35A2	
C-205	0150-0023	Capacitor, 0.002 uf, 1000 v.	Sprague	5GA-D20	2
C-206	0150-0023	Capacitor, 0.002 uf, 1000 v.	Sprague	5GA-D20	
C-207	0150-0023	Capacitor, 0.002 uf, 1000 v.	Sprague	5GA-D20	
C-208	0160-2031	Capacitor, Mica, 3.6 pf.	ARCO	DM-15	1
C-209	238-0022	Capacitor, 0.05 uf, 100 v.	AEROVOX	TTD	
C-301	0180-0326	Capacitor, elec, 250 uf, 50 v.	Sprague	TVA 1312	1
CR-101	1901-0157	Diode, silicon	Solitron	HC-30	3
CR-102	1901-0157	Diode, silicon	Solitron	HC-30	
CR-103	1901-0157	Diode, silicon	Solitron	HC-30	
CR-104	1901-0157	Diode, silicon	Solitron	HC-30	
CR-105	1901-0016	Diode, germanium	Transitron	T12G	4
CR-106	1901-0016	Diode, germanium	Transitron	T12G	
CR-107	1901-0016	Diode, germanium	Transitron	T12G	
CR-108	1901-0016	Diode, germanium	Transitron	T12G	
CR-109	1901-0016	Diode, germanium	Transitron	T12G	
CR-110	1901-0016	Diode, germanium	Transitron	T12G	
CR-111	1901-0016	Diode, germanium	Transitron	T12G	
CR-112	1901-0016	Diode, germanium	Transitron	T12G	
CR-113	1901-0016	Diode, germanium	Transitron	T12G	
CR-114	1901-0016	Diode, germanium	Transitron	T12G	
CR-115	1901-0016	Diode, germanium	Tranistron	T12G	

FIGURE 7-1. PARTS LIST AND RECOMMENDED SPARES (Sheet 1 of 4)

ircuit mbol	HP Part No.	Description	Typical Mfrs	Mfrs Designation	RS
R-116	1901-0016	Diode, germanium	Transitron	T12G	
R-117	1901-0191	Diode, silicon	Semtech	SC-1	
R-118	1901-0191	Diode, silicon	Semtech	SC-1	2
R-119	1901-0191	Diode, silicon	Semtech	SC-1	
R-120	1902-0775	Diode, zener 24 v., 3 w.	UTC	UZ824	1
R-201	1901-0016	Diode, germanium	Transitron	T12G	5
R-202	1901-0016	Diode, germanium	Transitron	T12G	
R-203	1901-0016	Diode, germanium	Transitron	T12G	
R-204	1901-0016	Diode, germanium	Transitron	T12G	
R-205	1901-0016	Diode, germanium	Transitron	T12G	
R-206	1901-0016	Diode, germanium	Transitron	T12G	
R-207	1901-0157	Diode, silicon	Solitron	HC-30	
R-208	1901-0016	Diode, germanium	Transitron	T12G	
R-209	1901-0016	Diode, germanium	Transitron	T12G	
R-210	1901-0016	Diode, germanium	Transitron	T12G	
R-211	1901-0016	Diode, germanium	Transitron	T12G	
R-212	1901-0016	Diode, germanium	Transitron	T12G	
R-213	1901-0016	Diode, germanium	Transitron	T12G	
R-214	1901-0016	Diode, germanium	Transitron	T12G	
R-215	1901-0016	Diode, germanium	Transitron	T12G	
R-216	1901-0016	Diode, germanium	Transitron	T12G	
J01	A10582	Connector, 10 pin	HP		
J02	A9245	Connector, 10 pin	HP		
K301	0490-0166	Relay, DPDT, 2.5 K, 5.8 ma.	Allied Control		
K302	0490-0166	Relay, DPDT, 2.5 K, 5.8 ma.	Allied Control	TS-154-CC-5.8	
R101	0684-1831	Resistor, comp, 18 K, 1/4 w. 10%	Allen-Bradley		1
R102	0684-1831	Resistor, comp, 18 K, 1/4 w. 10%	Allen-Bradley		
R103	0684-2221	Resistor, comp, 2.2 K, 1/4 w. 5%	Allen-Bradley		1
R104	0683-2025	Resistor, comp, 2 K, 1/4 w. 5%	Allen-Bradley		
R105	factory selected	Resistor, (approx. 100 K)	Allen-Bradley		
R106	2100-0887	Resistor, variable, 20 K	Bourns 3067P		
R107	0684-5621	Resistor, comp, 5.6 K, 1/4 w. 10%	Allen-Bradley		1
R108	0684-1041	Resistor, comp, 100 K, 1/4 w. 10%	Allen-Bradley		
R109	0684-2231	Resistor, comp, 22 K, 1/4 w. 5%	Allen-Bradley		
R110	0684-1031	Resistor, comp, 10 K, 1/4 w. 10%	Allen-Bradley		
R111	0684-0145	Resistor, comp, 1 K, 1/4 w. 10%	Allen-Bradley		
R112	0684-1031	Resistor, comp, 10 K, 1/4 w. 10%	Allen-Bradley		
R113	factory selected	Resistor, (approx. 10 K)	Allen-Bradley		
R114	0684-4725	Resistor, comp, 4.7 K, 1/4 w. 5%	Allen-Bradley		
R115	0684-8221	Resistor, comp, 8.2 K, 1/4 w. 10%	Allen-Bradley		1
R116	0684-1031	Resistor, comp, 10 K, 1/4 w. 10%	Allen-Bradley		
R117	0684-6811	Resistor, comp, 680 ohms, 1/4 w. 10%	Allen-Bradley		
R118	0684-2231	Resistor, comp, 22 K, 1/4 w. 5%	Allen-Bradley		1
R119	0684-1031	Resistor, comp, 10 K, 1/4 w. 5%	Allen-Bradley		1
R120	0684-6821	Resistor, comp, 6.8 K, 1/4 w. 10%	Allen-Bradley		
R121	0684-6821	Resistor, comp, 6.8 K, 1/4 w. 10%	Allen-Bradley		
R122	0684-1521	Resistor, comp, 1.5 K, 1/4 w. 10%	Allen-Bradley		
R123	0684-0145	Resistor, comp, 1 K, 1/4 w. 10%	Allen-Bradley		
R124	0684-1041	Resistor, comp, 100 K, 1/4 w. 10%	Allen-Bradley		1
R125	0684-1041	Resistor, comp, 100 K, 1/4 w. 10%	Allen-Bradley		
R126	0684-3941	Resistor, comp, 390 K, 1/4 w. 5%	Allen-Bradley		1
R127	0684-3931	Resistor, comp, 39 K, 1/4 w. 10%	Allen-Bradley		1
R128	0684-4731	Resistor, comp, 47 K, 1/4 w. 10%	Allen-Bradley		
R129	0684-2221	Resistor, comp, 2.2 K, 1/4 w. 5%	Allen-Bradley		1
R130	0684-2231	Resistor, comp, 22 K, 1/4 w. 5%	Allen-Bradley		1
R131	0684-2211	Resistor, comp, 220 ohm, 1/4 w. 10%	Allen-Bradley		1
R132	0684-2231	Resistor, comp, 22 K, 1/4 w. 5%	Allen-Bradley		
R133	0684-1031	Resistor, comp, 10 K, 1/4. 10%	Allen-Bradley		
R134	0684-1031	Resistor, comp, 10 K, 1/4 w. 10%	Allen-Bradley		
R135	0684-1031	Resistor, comp, 10 K, 1/4 w. 10%	Allen-Bradley		
R136	0684-3321	Resistor, comp, 3.3 K, 1/4 w. 10%	Allen-Bradley		
R137	0683-3615	Resistor, comp, 360 ohm, 1/4 w. 5%	Allen-Bradley		1

FIGURE 7-1. PARTS LIST AND RECOMMENDED SPARES (Sheet 2 of 4)

Circuit Symbol	HP Part No.	Description	Typical Mfrs	Mfrs Designation	RS
R-138	0684-3321	Resistor, comp, 3.3 K, 1/4 w. 10%	Allen-Bradley		1
R-139	0684-1031	Resistor, comp, 10 K, 1/4 w. 10%	Allen-Bradley		
R-140	0684-2721	Resistor, comp, 2.7 K, 1/4 w. 5%	Allen-Bradley		1
R-141	0690-1011	Resistor, comp, 100 ohm, 1/4 w. 10%	Allen-Bradley		1
R-142	0684-2721	Resistor, comp, 2.7 K, 1/4 w. 5%	Allen-Bradley		
R-201	0683-1055	Resistor, comp, 1 meg., 1/4 w. 10%	Allen-Bradley		1
R-202	0684-1531	Resistor, comp, 15 K, 1/4 w. 10%	Allen-Bradley		2
R-203	0684-1531	Resistor, comp, 15 K, 1/4 w. 10%	Allen-Bradley		
R-204	0684-1531	Resistor, comp, 15 K, 1/4 w. 10%	Allen-Bradley		
R-205	0684-1531	Resistor, comp, 15 K, 1/4 w. 10%	Allen-Bradley		
R-206	0684-1531	Resistor, comp, 15 K, 1/4 w. 10%	Allen-Bradley		
R-207	0684-3331	Resistor, comp, 33 K, 1/4 w. 10%	Allen-Bradley		
R-208	0684-4721	Resistor, comp, 4.7 K, 1/4 w. 10%	Allen-Bradley		
R-209	0683-1025	Resistor, comp, 1 K, 1/4 w. 5%	Allen-Bradley		
R-210	0683-1231	Resistor, comp, 12 K, 1/4 w. 10%	Allen-Bradley		
R-211	0684-1031	Resistor, comp, 10 K, 1/4 w. 10%	Allen-Bradley		
R-212	0684-2231	Resistor, comp, 22 K, 1/4 w. 5%	Allen-Bradley		
R-213	0683-2445	Resistor, comp, 300 K, 1/4 w. 5%	Allen-Bradley		
R-214	0684-1531	Resistor, comp, 15 K, 1/4 w. 10%	Allen-Bradley		
R-215	0684-8221	Resistor, comp, 8.2 K, 1/4 w. 10%	Allen-Bradley		
R-216	0684-2231	Resistor, comp, 22 K, 1/4 w. 5%	Allen-Bradley		
R-217	0683-1025	Resistor, comp, 1 K, 1/4 w. 5%	Allen-Bradley		
R-218	0684-3331	Resistor, comp, 33 K, 1/4 w. 10%	Allen-Bradley		
R-219	0684-6821	Resistor, comp, 6.8 K, 1/4 w. 10%	Allen-Bradley		
R-220	0684-2231	Resistor, comp, 22 K, 1/4 w. 5%	Allen-Bradley		
R-221	0690-1011	Resistor, comp, 100 ohm, 1/4 w. 10%	Allen-Bradley		
R-222	0684-4721	Resistor, comp, 4.7 K, 1/4 w. 10%	Allen-Bradley		
R-223	0684-4721	Resistor, comp, 4.7 K, 1/4 w. 10%	Allen-Bradley		
R-224	0684-3331	Resistor, comp, 33 K, 1/4 w. 10%	Allen-Bradley		
R-225	0684-8221	Resistor, comp, 8.2 K, 1/4 w. 5%	Allen-Bradley		
R-226	0684-3321	Resistor, comp, 3.3 K, 1/4 w. 10%	Allen-Bradley		
R-227	0684-2231	Resistor, comp, 22 K, 1/4 w. 5%	Allen-Bradley		
R-228	0684-2231	Resistor, comp, 22 K, 1/4 w. 5%	Allen-Bradley		
R-229	0684-2231	Resistor, comp, 22 K, 1/4 w. 5%	Allen-Bradley		
R-230	0684-2231	Resistor, comp, 22 K, 1/4 w. 5%	Allen-Bradley		
R-231	0684-2231	Resistor, comp, 22 K, 1/4 w. 5%	Allen-Bradley		
R-232	0684-1031	Resistor, comp, 10 K, 1/4 w. 10%	Allen-Bradley		
R-233	0684-1031	Resistor, comp, 10 K, 1/4 w. 10%	Allen-Bradley		
R-234	0684-4711	Resistor, comp, 470 ohm, 1/4 w. 10%	Allen-Bradley		
R-235	0684-5621	Resistor, comp, 5.6 K, 1/4 w. 10%	Allen-Bradley		
R-236	0684-2231	Resistor, comp, 22 K, 1/4 w. 5%	Allen-Bradley		
R-237	0684-1031	Resistor, comp, 10 K, 1/4 w. 10%	Allen-Bradley		
R-238	0683-1055	Resistor, comp, 1 meg., 1/4 w. 10%	Allen-Bradley		
T-301	9100-1509	Transformer, power	TRIAD 68911		1
TR-101	1851-0017	Transistor	Texas Inst.	2N1302	4
TR-102	1850-0062	Transistor	Texas Inst.	2N1303	4
TR-103	1851-0017	Transistor	Texas Inst.	2N1303	
TR-104	1850-0062	Transistor	Texas Inst.	2N1303	
TR-105	1850-0062	Transistor	Texas Inst.	2N1303	
TR-106	1850-0062	Transistor	Texas Inst.	2N1303	
TR-107	1850-0062	Transistor	Texas Inst.	2N1303	
TR-108	1850-0062	Transistor	Texas Inst.	2N1303	
TR-109	1851-0017	Transistor	Texas Inst.	2N1302	
TR-110	1851-0017	Transistor	Texas Inst.	2N1302	
TR-201	1851-0017	Transistor	Texas Inst.	2N1302	
TR-202	1851-0025	Transistor	Texas Inst.	2N1308	
TR-203	1851-0025	Transistor	Texas Inst.	2N1308	
TR-204	1851-0025	Transistor	Texas Inst.	2N1306	
TR-205	1851-0062	Transistor	Texas Inst.	2N1303	
TR-206	1850-0062	Transistor	Texas Inst.	2N1303	
TR-207	1850-0062	Transistor	Texas Inst.	2N1303	
TR-208	1851-0017	Transistor	Texas Inst.	2N1302	
TR-209	1851-0017	Transistor	Texas Inst.	2N1302	
TR-210	1851-0025	Transistor	Texas Inst.	2N1306	

FIGURE 7-1. PARTS LIST AND RECOMMENDED SPARES (Sheet 3 of 4)

Circuit Symbol	HP Part No.	Description	Typical Mfrs	Mfrs Designation	RS
		G-2A (only) refer to C-12569			
-101	A-12727	Switch, rotary	HP		1
	A-11795	Insulator, circuit board (2 each)	HP		
		G-2B (only) refer to C-12570			
-101	A-12728	Switch, rotary	Moseley		
-102	3101-0045	Switch, slide	Muter	#11275	1
-103	1251-1052	Receptacle, 5 pin-male Mate 1251-0278	Amphenol		
-101	1251-1049	Connector, 10 pin	Amphenol		
-102	1251-1049	Connector, 10 pin	Amphenol		
-104	1251-0283	Plug, 12 pin	Amphenol		
-102	0686-9135	Resistor, comp, 91 K, 1/2 w. 5%	Allen-Bradley		
-103	0686-9135	Resistor, comp, 91 K, 1/2 w. 5%	Allen-Bradley		

FIGURE 7-1. PARTS LIST AND RECOMMENDED SPARES (Sheet 4 of 4)

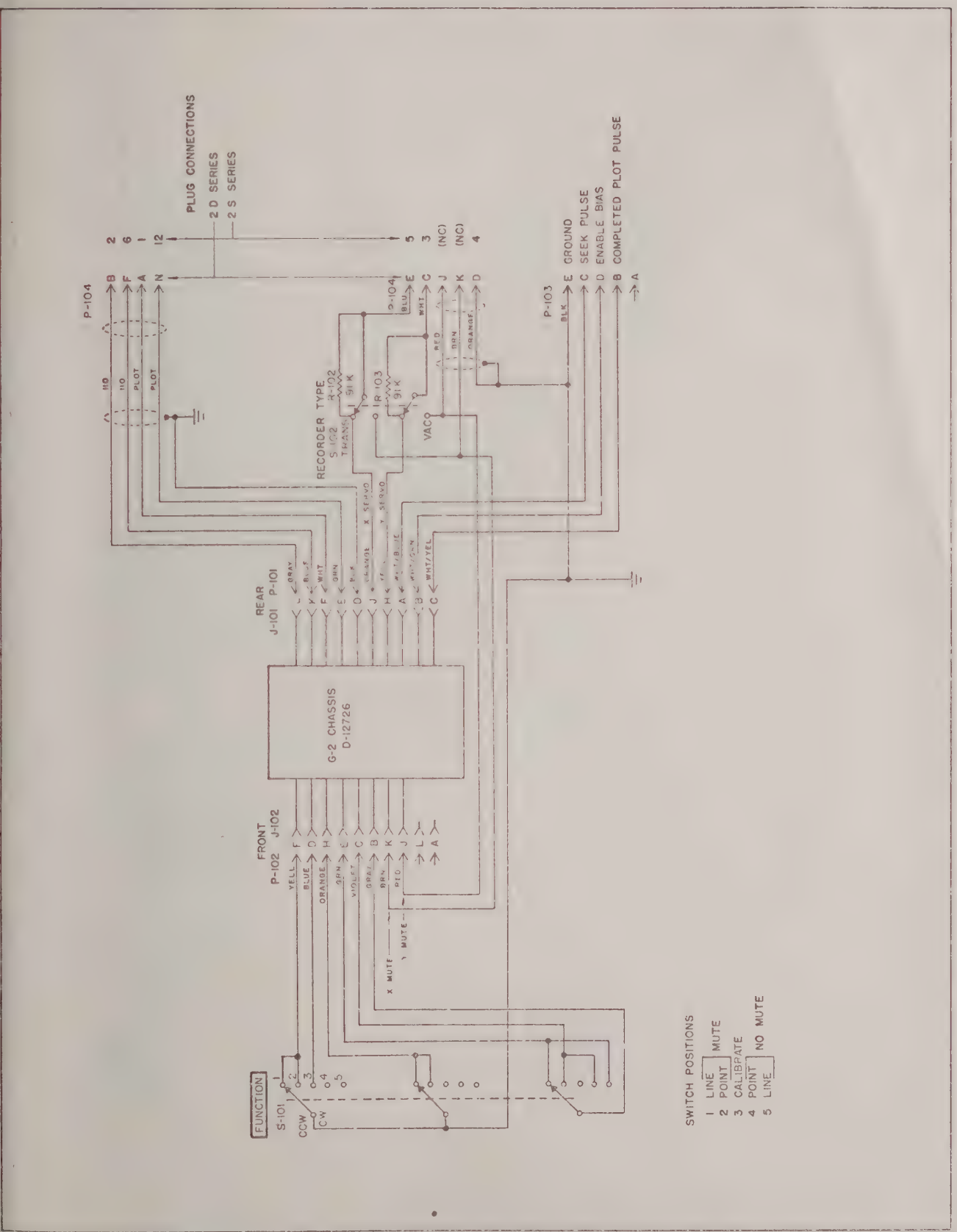


FIGURE 7-2. G2B INSTALLATION SCHEMATIC S/N 146 AND UP C-12570

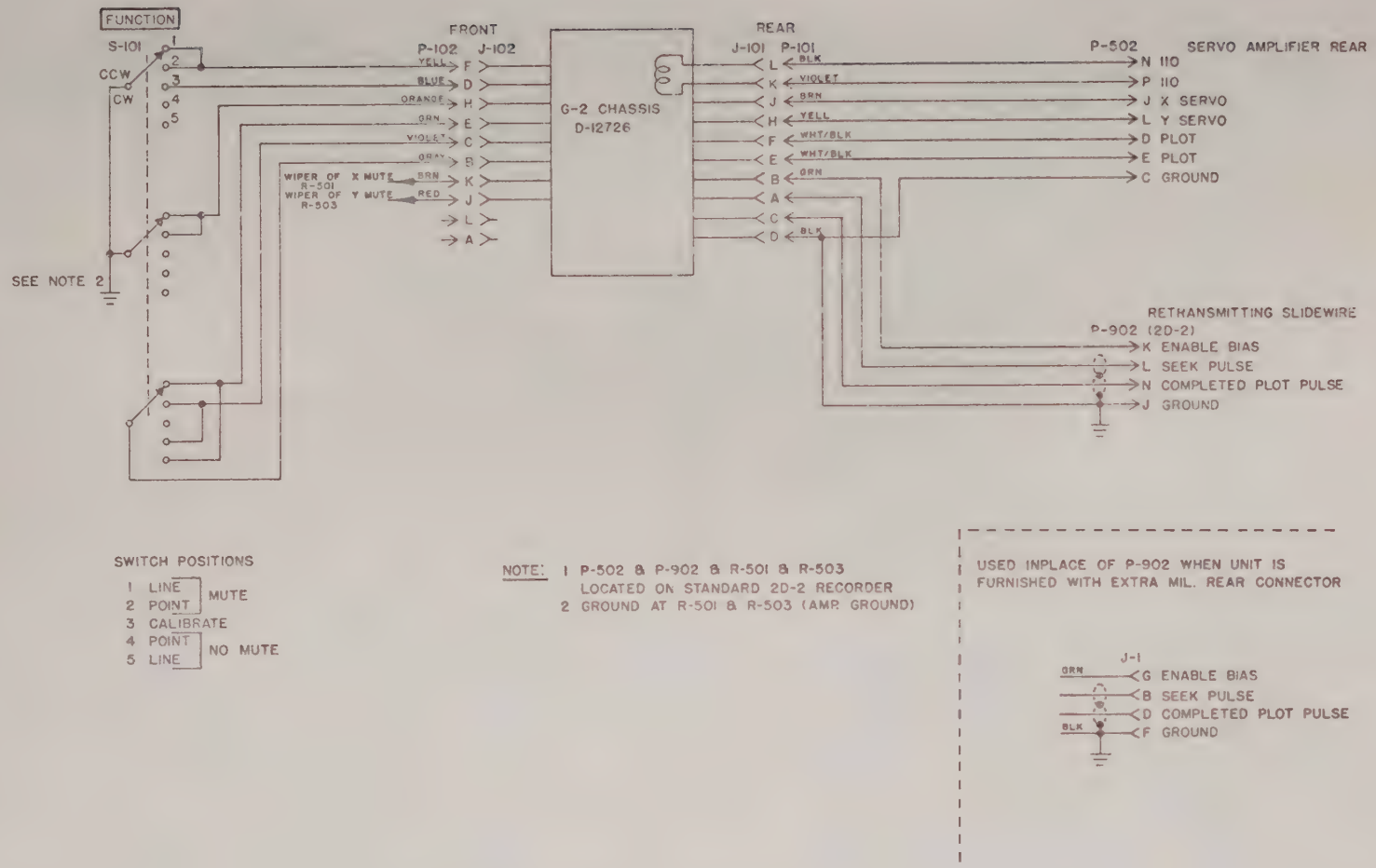


FIGURE 7-3. G2 WIRING CONNECTIONS (2D2) S/N 146 AND UP C-12569

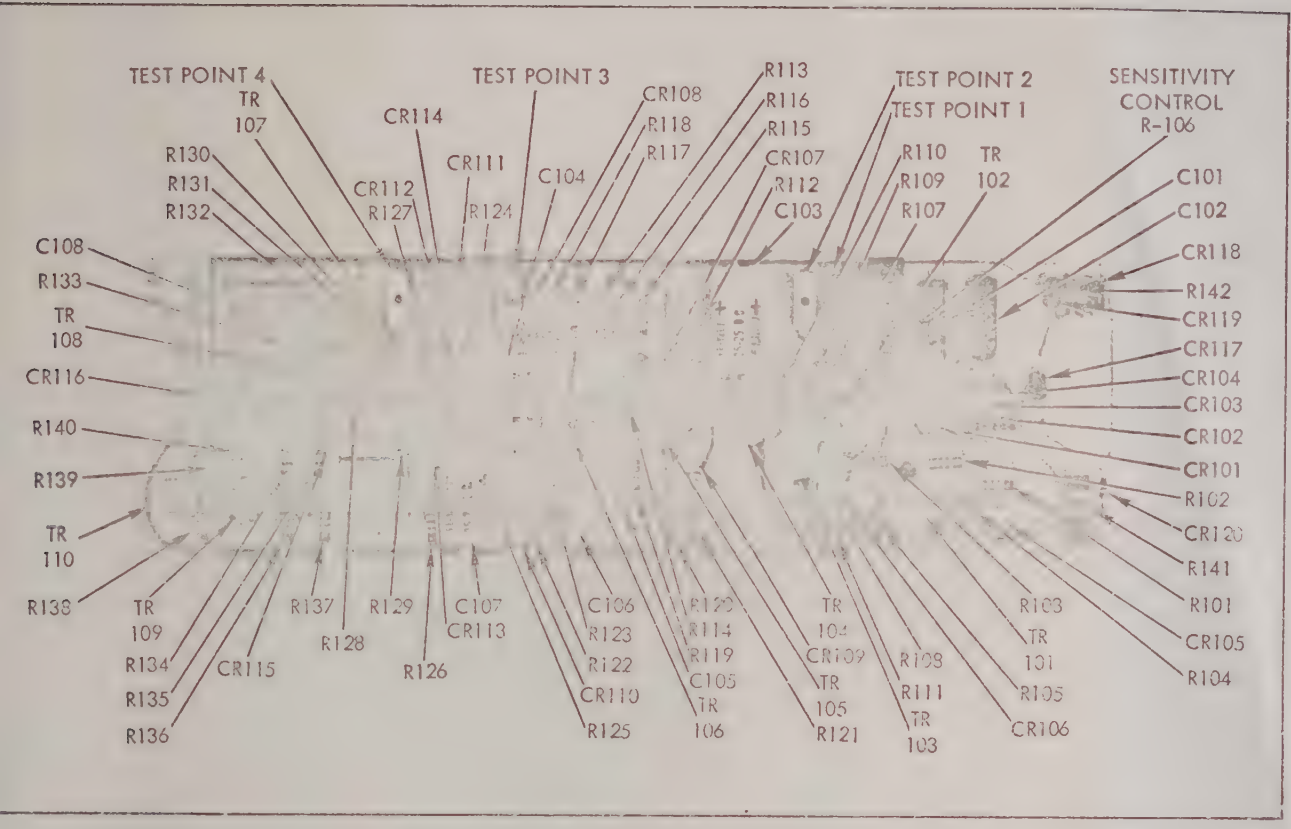


FIGURE 7-4. PRINTED CIRCUIT BOARD "A"

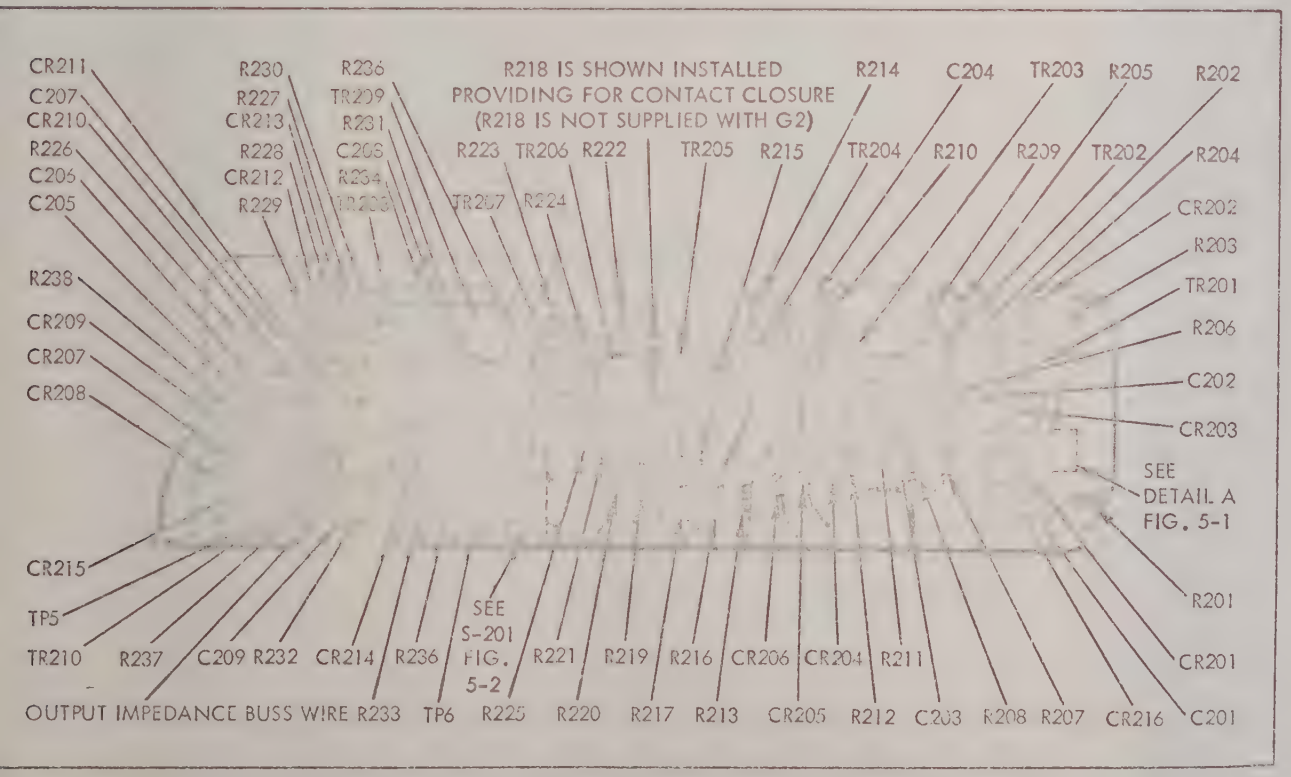
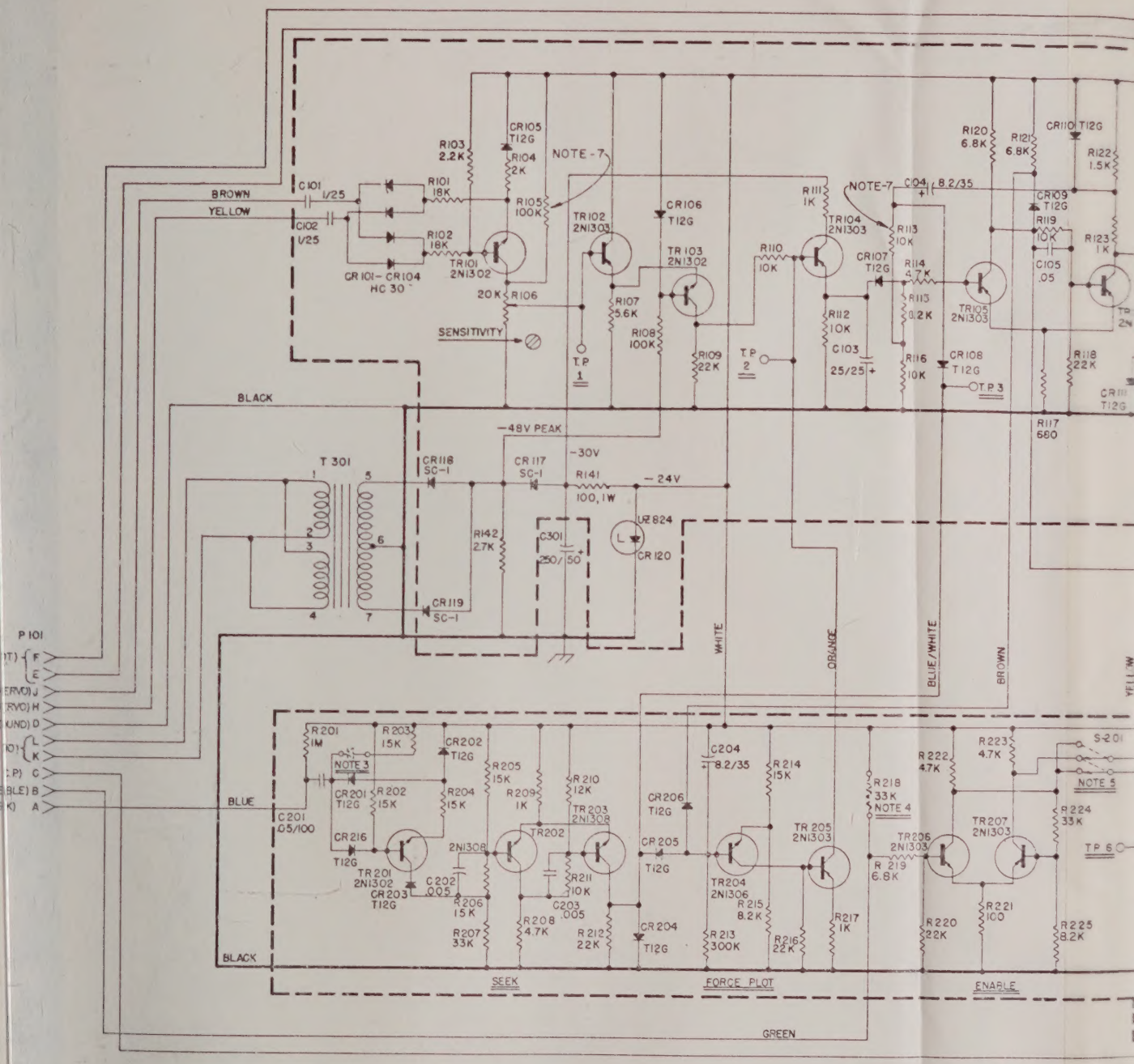


FIGURE 7-5. PRINTED CIRCUIT BOARD "B"



NOTES:

1. ALL RESISTORS ARE 1/4 WATT UNLESS INDICATED OTHERWISE
2. ALL CAPACITANCE VALUES ARE IN MICROFARADS UNLESS INDICATED OTHERWISE
3. MODIFICATION REQUIRED FOR PULSE WIDTHS GREATER THAN 80 MS. REFER TO INSTRUCTION MANUAL
4. RESISTOR MAY BE INSTALLED TO OPERATE ENABLE CIRCUIT WITH CONTACT CLOSURE TO GROUND
5. BIAS REQUIREMENT MAY BE REVERSED BY CHANGING JUMPERS AS INDICATED
6. OUTPUT IMPEDANCE MAY BE RAISED BY INSTALLING AN APPROPRIATE VALUE RESISTOR
7. FACTORY SELECTED VALUE, VALUE SHOWN IS TYPICAL

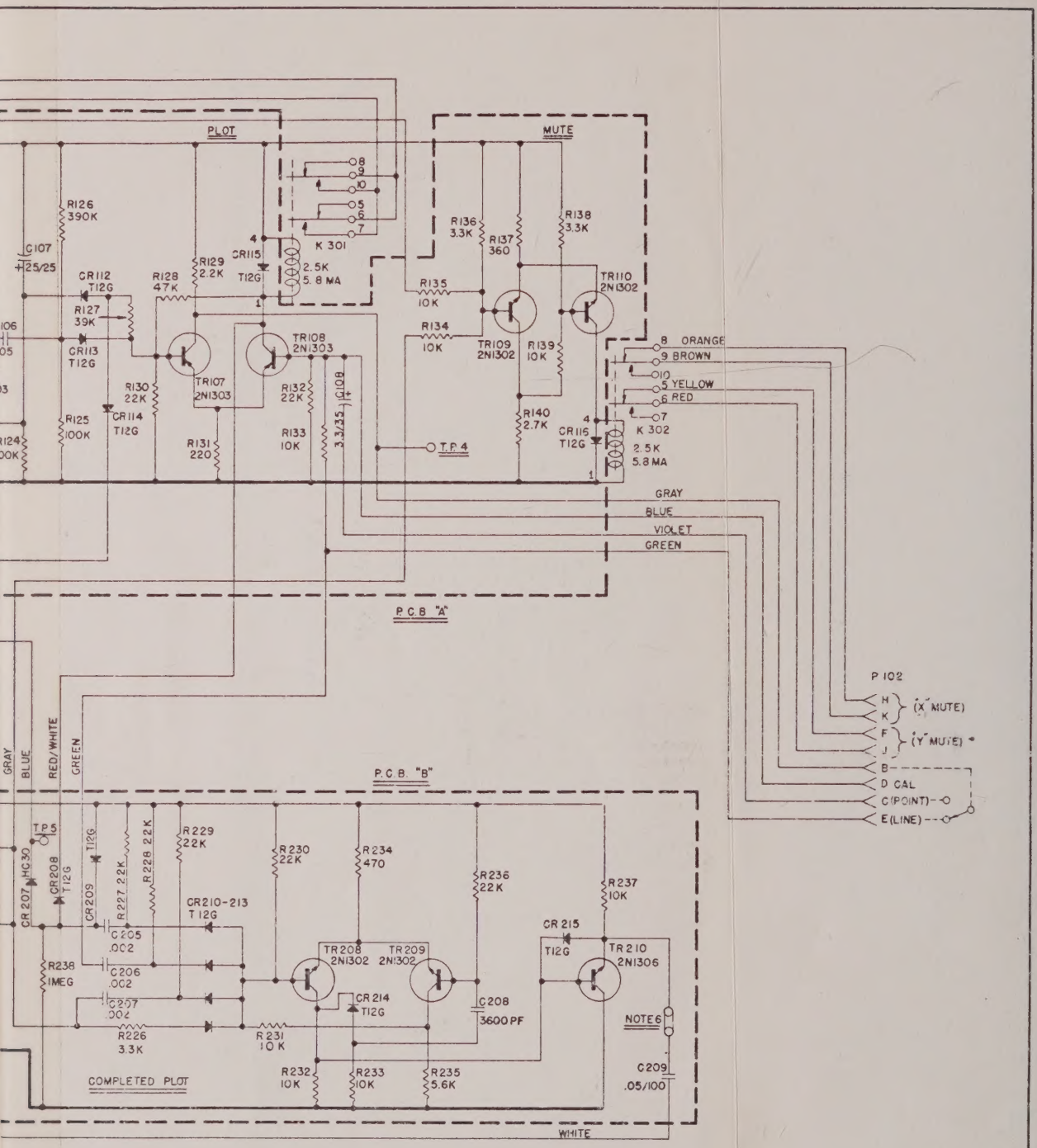


FIGURE 7-6. G2/G2B NULL DETECTOR SCHEMATIC S/N 146 AND UP D12726